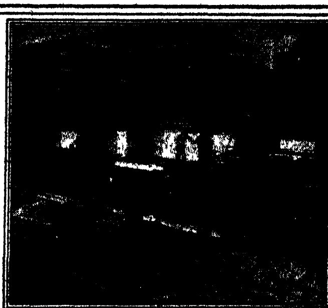
# CONDUIT WIRING

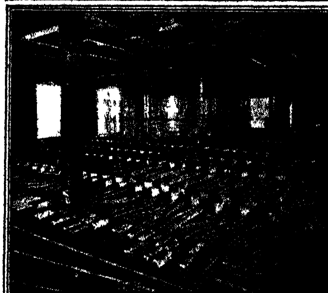
*The quality of the materials used in the manufacture of this book is governed by continued postwar shortages.*

I-Switchboard Substation
*Conduit Elbow Fittings Serve As Pull Boxes. Fiber Conduit Nipples Through Floor.*

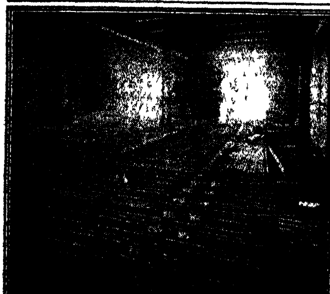


II-Switchboard Substation
*Conduit On Main Floor And On Galley "Tied" In Place And Almost Ready For Pouring Concrete.*

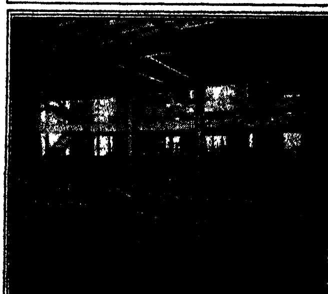
III Switchboard Substation
*Conduits Terminate In Templets To The Left Which Will Form A Trench Back Of The Switchboard.*



IV Main Floor Switchhouse
*The Rectangular Objects Are Pull Boxes Which Will Open To The Ceiling Of The Story Below.*



V-Main Floor Switchhouse
*Conduit All Ready For The Pouring Of Concrete Note Improvised Pipe Benches On The Columns.*



VI-Control Room
*Conduit Wired In Place Over Steel Wire Mesh Reinforcing Note The Method Of Bracing The Turned-Up Elbow With A Wire Tie.*

(*Frontispiece*).

**Examples of "roughed-in" conduit wiring in the Essex Power Station of the Public Service Electric Company, Newark, New Jersey. A total of 203,000 ft. (about 38.5 mi.) of conduit was used in this installation. Of this about 4,800 ft. was brass pipe, employed to minimize losses and heating due to inductive fields from nearby conductors carrying large currents.**

# CONDUIT WIRING

BY

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# PREFACE

CONDUIT WIRING, as the title implies, deals exclusively with the conduit method of interior wiring—which has become by far the most important of all of the methods. This wiring method has been briefly treated in many available books on interior wiring. But such brief treatments of this significant subject are now, however, no longer deemed adequate. The conduit method is employed so extensively and is so rapidly superceding the others that a detailed exposition appears to be timely.

This book has been written primarily for the man who installs or who directs the installation of the wiring. However, it should be equally useful to the engineer, architect or superintendent who plans the installation; he can learn from it the modern methods and procedure in installing a conduit wiring system. Wiremen should, with the aid of this book, when given the plans and specifications for a conduit job—large or small—be able properly to install it. The steps and operations which must be followed in installing conduit wiring, in accordance with modern practice, are discussed and explained in a thoroughly practical way. The usual procedures which are followed in installing jobs of all kinds (from the small ones in residences up to those in the largest office buildings and industrial plants) are discussed. Conduit wiring in reinforced-concrete structures is accorded special consideration.

More than 700 illustrations, the drawings for which were especially made for this work, have been included—to present graphically the various concepts. It has been the endeavor to so design and render these pictures that they will convey the desired information with a minimum of supplementary text.

As to method of treatment; In Div. 1, the manner in which the book should be studied by various persons is discussed. Then follows a description of the different materials and supplies which are used in conduit-wiring installations. In

the next division, *Laying Out A Conduit Job*, the methods of making plans for either small-residence or large-building conduit installations are described.

"Roughing in" of the conduit, which includes the manipulation of the conduit and the tools required for it, the installing of concealed conduit, and the installing of exposed conduit, is then treated in the following 3 divisions. In the next group of divisions are considered the installation, testing out, and connection of the conductors and the grounding of the conduit system. These steps complete the installation.

In the final 3 divisions, are discussed the application of conduit wiring for special services. These include: *Conduit For Telephone Circuits*, *Conduit Wiring In Damp And Otherwise Hazardous Places*, and *Conduit Wiring On Machinery*. In the division on *Conduit Wiring In Damp And Otherwise Hazardous Places*, the relative merits of conduit wiring as compared with wiring in such places, are presented.

With this, as with other books which have been prepared by the author, it is the sincere desire to render it of maximum usefulness to the reader. It is the intention to improve the book each time it is revised and to enlarge it as conditions may demand. If these things are to be accomplished most effectively, it is essential that the readers cooperate with us. This they may do by advising the author of alterations which they feel it would be advisable to make. Future revisions and additions will, insofar as is feasible, be based on such suggestions and criticisms from the readers.

Although the proofs have been read and checked very carefully by a number of persons, it is possible that some undiscovered errors may remain. Readers will confer a decided favor in advising the author of any such errors.

TERRELL CROFT.

UNIVERSITY CITY,
ST. LOUIS, MO.
*December*, 1923.

# ACKNOWLEDGMENTS

The author desires to acknowledge the assistance which has been rendered by a number of concerns and individuals in the preparation of this book. Considerable of this material appeared originally as articles (written by the author) in engineering papers and technical periodicals among which are: *Electrical Review & Western Electrician, Metal Worker, Plumber & Steam Fitter, Popular Mechanics, Power, Electrical Engineer, Power Plant Engineering, Railway Master Mechanic, Coal Age, National Engineer, Electrical Experimenter, Practical Engineer, Electrical World, Power House, Southern Engineer, Canadian Engineer, Electrical Record, Electrical South, Sanitary & Heating Engineer* and *Electrical Merchandising.* Acknowledgment is hereby accorded to these publications for their permission to use in this book the information which was originally given in the articles.

Among the concerns which cooperated in supplying text data or material for illustrations are:

*Frank Adam Electric Co.*
*M. B. Austin & Co.*
*Crouse-Hinds Company*
*Chicago Fuse Mfg. Co.*
*National Conduit Wiring Co.*
*Pedrick Tool & Machine Co.*
*Pneumatic Conduit Threader Co.*
*H. P. Martin & Sons.*
*General Electric Co.*
*Sprague Electric Works*
*The Borden Company*
*The Thomas & Betts Co.*
*The Toledo Pipe Threading Machine Co.*
*Wabash Shops, Decatur, Ill.*
*Wiring Equipment Co.*
*Rick-Chapline Electric Co.*

Considerable of the text and illustrative material has been based on that in *United States Army Educational Manual No. 13—Interior Wiring*, which was developed in the Army School at Camp Grant, Illinois, under the direction of Dean R. W. Selvidge of the University of Missouri. The manual for Interior Wiring was prepared by Mr. A. H. Fensholt and Mr. O. B. Fensholt.

Special acknowledgment is hereby accorded to I. V. LeBow, *Head Electrical Engineer of* THE TERRELL CROFT ENGINEERING COMPANY, who carefully read and checked the manuscript and illustration drawings and also furnished many valuable suggestions during their preparation. The editor author also wishes to acknowledge the assistance of Edmond Siroky, *Head Mechanical Engineer* and of Earl Bumiller, *Mechanical Engineer* of THE TERRELL CROFT ENGINEERING COMPANY who prepared certain of the divisions, accorded useful advice, and who are largely responsible for much of the material in the book.

Other acknowledgments have been made throughout the book. If any has been omitted, it has been through oversight; if brought to the editor's attention, it will be incorporated in the next edition.

# CONTENTS

# CONDUIT WIRING

## DIVISION 1

### HOW TO STUDY THIS BOOK

**1. The Function Of This Division** is to guide the reader to the most effective use of the book. To this end it is proposed to explain here the general procedure in installing conduit wiring and the relation of the different divisions of this book to this procedure.

NOTE.—THE BOOK NEED NOT, NECESSARILY, BE READ CONSECUTIVELY. The inexperienced man will, probably, do well to start at the beginning and study through the divisions of the book in the order in which they are given. This order follows approximately the sequence in which the different steps, in the installation of a conduit job, occur. Thus, the consecutive reading of the book will, in effect, be equivalent to following through the installation of a conduit job—from start to finish. But the experienced man can profitably employ the different divisions of the book as tools, using them solely for reference.

**2. Table Showing General Procedure In Installing A Conduit Wiring Job.** The 5 "general divisions" of work which are shown are those into which the jobs are ordinarily divided —either actually or by implication—by conduit-wiring contractors. It should be understood that this table recites the *general* procedure for the *average* job. The detail procedure which should be followed for any given job may vary considerably from that which is here outlined. Ordinarily the different steps are taken in about the order which is indicated.

| General divisions | Subdivisions |
|---|---|
| 1<br>Preliminary Work | (a) Getting architect's or engineer's latest revised plans and specifications.<br>(b) Selection of materials and supplies.<br>(c) Ordering the materials and supplies.<br>(d) Issuing the work orders.<br>(e) Laying out the job. |
| 2.<br>Roughing In | (a) Roughing in conduit.<br>(b) Roughing in conduit boxes.<br>(c) Roughing in switch, panel, and distributing cabinets.<br>(d) First examination by electrical inspector |
| 3.<br>Pulling In | (a) Cleaning the conduit raceway.<br>(b) "Fishing" the conduit.<br>(c) Pulling in branch-circuit conductors.<br>(d) Pulling in feeders and mains.<br>(e) Pulling in service conductors (if any).<br>(f) Pulling in signal-circuit and other low-tension conductors. |
| 4.<br>Finishing | (a) "Testing out," splicing, and taping.<br>(b) Grounding the conduit system.<br>(c) Installing and connecting panel boards<br>(d) Installing and connecting entrance equipment, main switchboard, and sub switchboards.<br>(e) Installing and connecting lighting fixtures, wiring devices, and fittings.<br>(f) Installing and connecting power apparatus<br>(g) Installing and connecting signal-circuit and other low-tension apparatus.<br>(h) Installing panel and other box trims and making necessary adjustments thereof. Installing switch and receptacle plates and other outlet covers, if not already done. |
| 5.<br>Final Work | (a) Final trying out.<br>(b) Final adjustments, if any.<br>(c) Final insulation-resistance test.<br>(d) Final examination by electrical inspector.<br>(e) Removing tools and surplus material from the job. |

**3. The Arrangement Of Topics In This Book** does not precisely follow the classifications of Table 2. This will be evident from a consideration of the Contents which is given on front-matter, page xi. The reason for this deviation is that the topics and sequence which were selected (as shown in the Contents) appeared to permit of a more convenient and effective development than would an arrangement which followed exactly the grouping which is specified by Table 2. The topics of the

"general divisions" of the above table will now be considered; directions for locating information on certain of the subdivision subjects will be given.

**4. "Preliminary-work"** information is given in Div. 2, "Conduit-wiring Material And Supplies," and in Div. 3 "Laying Out A Conduit Job;" also for signal-circuit information see Div. 11, "Conduit For Telephone Circuits." See Div. 12 concerning supplies which should be used in hazardous places. No effort is made herein to treat preliminary-work "subdivisions" (*a*), (*c*) and (*d*) of Table 2.

**5. "Roughing In"** in "non-hazardous" places for concealed conduit is discussed in Div. 5, and for exposed conduit in Div. 6. In Div. 11 is given information concerning the roughing in of telephone and other signal circuits conduit. See Div. 12 for conduit installation in hazardous places.

NOTE.—THE FIRST EXAMINATION BY THE ELECTRICAL INSPECTOR (subdivision 2*d*, Table 2) is usually made, after or just prior to the completion of the roughing in.

**6. "Pulling In"** is treated in general in Div. 7. See also Div. 12 for special precautions to be observed in installing conduit conductors in hazardous places.

**7. "Finishing"** for ordinary conditions is discussed in Divs. 5, 6, 8 and 9 and for hazardous places in Div. 12. No detail treatment of Table 2, subdivisions 4 (*c*), (*d*), (*e*), (*f*), (*g*), and (*h*) is attempted in this book.

**8. "Final Work"** is considered in Div. 10. Usually the last steps of a conduit job are the "final examination" after the completion of the installation, by the electrical inspector (subdivision 5*d*) and the removal of the "leftovers" (subdivision 5*e*) from the job. Neither of these two latter topics is discussed further herein.

## QUESTIONS ON DIVISION 1

1. What, probably, is the best method for an inexperienced man who is studying this book to pursue? For an experienced man?
2. Prepare a table showing the 5 general divisions into which the work of a conduit job is generally considered as being divided.
3. Show the usual subdivisions, for the average job, for each of the 5 general divisions of Question 2.
4. When is the first examination by the electrical inspector made?
5. When is the final electrical examination usually made?

# DIVISION 2

## CONDUIT-WIRING MATERIAL AND SUPPLIES

**9. The Conduit Method Of Wiring** is gradually becoming the most important one for all interior-wiring installations. The system consists, primarily, of a tubular raceway, called the conduit, through which the insulated conductors are later pulled. The conduit protects the conductors from mechanical injury, permits the conductors to be easily withdrawn and others inserted (if defects are detected in them), and prevents the spreading of an arc should a short circuit occur in the conduit. Conduit may be made of any of various materials, such as fibre or the metals. But the conduit which is almost exclusively used in interior wiring is the metallic conduit. Fibre and other conduit is ordinarily used only in large central-station installations or in underground cable work. When, in interior-wiring parlance, the term "conduit" is used alone, metallic (steel) conduit is usually meant. The "National Electrical Code" applies only to metallic-conduit installations.

NOTE.—THE ONE DISADVANTAGE OF THE CONDUIT SYSTEM OF WIRING is its high cost; this disadvantage is generally, particularly in important installations, outweighed by its many advantages. In large industrial, commercial and residential structures conduit (generally rigid conduit) is now used almost exclusively in the initial installation. In small structures, residences for example, knob-and-tube work is still often used. Some large cities, such as Chicago, have passed ordinances requiring that all interior electric wiring be in conduit armored cable.

NOTE.—GREAT QUANTITIES OF CONDUIT ARE REQUIRED IN THE LARGE BUILDINGS.—In the Hotel Pennsylvania, New York, 635,000 ft. or 120 miles of conduit were used. In the Equitable Building, also of New York, 1,000,000 ft. or 190 miles of conduit were used. These two are, probably, the largest conduit installations in the country.

**10. Conduit Materials,** comprise principally: (1) *Conduit,* Sec. 12. (2) *Conduit cases,* Sec. 26. (3) *Conduit accessories,* Sec. 57. (4) *Conductors,* Sec. 68. (5) *Wiring devices.* Wiring

devices are not specifically treated in this division. The classification of conduit and conduit cases are given, respectively in Tables 11 and 25.

**11. Table Showing Classification Of Conduit.**

| | | | | |
|---|---|---|---|---|
| CONDUIT | NON-METALLIC (Not treated in this book) | | | |
| | METALLIC | STEEL | RIGID | Enameled.<br>Zinced.<br>Zinced outside—Enameled inside.<br>Zinced outside—Zinced and enameled inside.<br>Zinced and enameled, inside and outside. |
| | | | FLEXIBLE | Concave double strip.<br>Flat double strip.<br>Single strip. |
| | | NON-FERROUS (Aluminum, Brass, etc.) (Little used) | | |

**12. The Two Types Of Metallic Conduit Now Used** in interior wiring are (see Table 11): (1) *Flexible metallic conduit.* (2) *Rigid metallic conduit. Flexible metallic conduit* is made of strips of galvanized steel wrapped together in such a manner as to interlock each other and form a hollow tubing which is flexible. *Rigid metallic conduit,* commonly called iron conduit, is standard-weight, mild-steel pipe reamed to remove the burrs on the inside of the pipe and coated on both its interior and exterior surfaces with a protective covering of enamel—usually black—or zinc. The zinc or enamel coating prevents, or at least tends to prevent (Sec. 14), rusting or corrosion of the conduit. In this book, rigid metallic conduit will be treated more fully than metallic flexible conduit since it is more commonly used.

NOTE.—COMMON IRON OR MILD-STEEL PIPE USED AS RIGID CONDUIT is not approved by the "National Electric Code." The iron pipe usually

has burrs on its inside which would injure the insulation on the conductors. It likewise has no protective covering and so it would tend readily to corrode and rust. In spite of these facts, iron pipe, preferably galvanized iron pipe, is sometimes satisfactorily used in lieu of conduit in installations which will not be subject to inspection.

**13. Flexible Conduit Is Made In The Three Forms** (see Table 11): (1) *Concaved double strip.* (2) *Flat double strip.* (3) *Single strip.* These are shown in Fig. 1. The forms shown in Fig. 1-*I* and *II*, known as double strip, consist of two strips of galvanized steel, spirally wound upon each other. In each of these, a gasket is provided between the strips rendering the conduit fairly moisture proof. The form shown in Fig. 1-*III*, which is called single-strip flexible conduit, is formed from one strip of galvanized steel interlocked. That made by some manufacturers is also gasketed. The forms shown in Fig. 1-*I* and *II* have a smoother inner surface than that of the single-strip flexible conduit. Since the conduit should have as smooth an inner surface as possible (so that the conductors can be easily drawn through it) the double strip is usually preferred to the single strip. The double strip (Fig. 1-*I*) and *II*) is also more flexible than the single strip. Between the forms shown in Fig. 1-*I* and *II*, there is little to choose except that the form shown in part *II* is a little more flexible than that shown in part *I*, because of the flat sliding surfaces offered to the upturned edges of the strip.

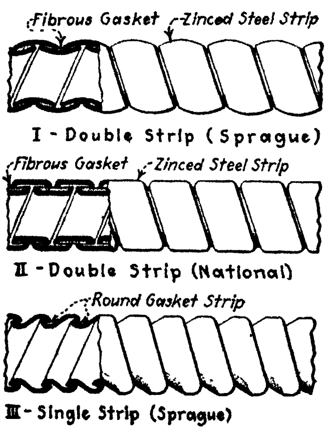


FIG. 1.—Three forms of metallic flexible conduit.

NOTE.—THE ADVANTAGES OF FLEXIBLE CONDUIT are that it is easily bent and thus is easily installed. Since it is supplied in lengths of 25 to 250 ft. depending on the size, no elbows and few couplings are required. Also no threading is required. It can be easily "fished" and is well adapted for wiring in finished (completed) buildings or in other places which are inaccessible. In wooden-construction buildings where the

conduit run is at right angles to the joint length, flexible conduit may be drawn through holes bored through the joist centers, which holes do not materially weaken the joist; but where rigid conduit is used in such buildings, it must, ordinarily, be laid in slots cut in the joist edges, which weaken the joists; see Sec. 183. However, flexible conduit is usually more expensive than rigid conduit and it does not afford the mechanical protection that rigid conduit does. It is not as satisfactory in damp places as is rigid conduit, since it has a joint which, although provided with a gasket, may allow water to enter. Thus it is seldom laid in concrete, although the "Code" does not prohibit its use therein.

Note.—Armored Cable is a cable which has an armored covering, which covering is similar to flexible conduit. The armored covering is wound directly on the conductors; that is, the cable conductors cannot easily be removed from the armor. It is sometimes made with a lead gasket, which seals the joints between the spiral strips, making it moisture-proof.

**14. Rigid-Conduit Manufacture** consists of removing the burrs on the inside of standard pipe and of applying a protective coating to the pipe. The burrs are generally removed by forcing a steel ball (the diameter of which is equal to that of the inside of the pipe) longitudinally through the pipe. After the burrs are removed the pipe is cleaned by pickling it in a sulphuric-acid bath. The sulphuric acid removes all of the scale and foreign matter from the pipe. The pipe is taken from the acid bath, washed in hot water to remove all of the acid, and then immediately coated with the enamel or zinc before it has had time to oxidize. Sometimes when a zinc coating is to be applied, the pipe is given a neutralizing alkaline bath and another washing in hot water. If the pipe is to be enameled it is given an enamel bath and baked. If the pipe is to have a zinc finish, the zinc is applied in some one of several ways, as in explained below.

**15. Rigid Steel Conduit May Be Divided Into Five Classes** according to the protective coating which is used, as follows (see Table 11): (1) *Enameled rigid conduit,* which has both its interior and exterior surfaces coated with a tough waterproof enamel which is baked on; the enamel is usually black. (2) *Zinced rigid conduit,* which has both its interior and exterior surfaces coated with zinc. (3) *Zinced-outside-and-enameled-inside rigid conduit,* which has its exterior surface coated with zinc and its interior surface coated with enamel. (4) *Zinced-*

*outside-and-zinced-and-enameled-inside rigid conduit,* which has its exterior surface coated with zinc and its interior surface coated with both zinc and enamel. (5) *Zinced-and-enameled, both inside and outside, rigid conduit,* which has a coating of zinc and enamel on both its interior and exterior surfaces.

**16. When The Steel Pipe Is To Be Given A Zinc Coating,** one of the three following methods may be used: (1) *Electro-galvanizing process.* (2) *Sherardizing process.* (3) *Hot-dipped-galvanizing process.*

**17. In The Electro-Galvanizing Process,** as the name implies, the zinc coating is deposited (electroplated) on only the outer surface of the conduit by means of an electric current. In plating, the cleaned pipe is submerged in a solution of zinc sulphate and therein forms the cathode of an electric circuit. A bar of zinc is also submerged in the same solution and forms the anode of the circuit. When an electric current is forced through this circuit by an outside source of voltage, zinc is thereby abstracted from the anode and deposited on the outer surface of the pipe by the electric current which flows from the anode to the cathode. The electro-galvanizing process is the one most commonly used for zincing conduit.

**18. In The Sherardizing Process** the cleaned pipe is placed in large metal drums together with zinc dust and then the whole is heated to a temperature of approximately 900° F. The zinc dust, which consists of finely powdered metallic zinc and zinc oxide, becomes vaporized by the heat and amalgamates with the metal at the surfaces of the pipe which is to be sherardized. Both the inner and outer surfaces of the pipe are thus zinced. The coating which results is not pure zinc but is an alloy of about 90 per cent zinc and 10 per cent iron and is more highly resistant to corrosion than is pure zinc.

**19. In The Hot-Dipped-Galvanizing Process,** the cleaned pipe is first immersed in a muriatic-acid bath and then into a molten-zinc bath. Thus both the inner and outer surfaces of the pipe are coated with zinc. After remaining in the bath for a few minutes the pipe is removed mechanically and run through a machine which wipes the molten zinc into the conduit on both the interior and exterior surfaces.

NOTE.—THERE ARE MANY DIFFERENT MAKES OF ZINCED RIGID CONDUIT ON THE MARKET, called by various trade names, but nearly all of them are coated by either the electro-galvanizing or sherardizing processes. The hot-dipping process is seldom used because its cost is usually about double that of the sherardizing process. The Sprague Electric Works, however, makes a hot-dipped-galvanized conduit which, at the time of the writing, sells for about the same price as the other standard makes of zinced rigid conduit.

NOTE.—HOT-DIPPED-GALVANIZED CONDUIT IS BELIEVED TO WITHSTAND CORROSION BETTER THAN ZINCED CONDUIT COATED BY EITHER OF THE OTHER TWO METHODS.—The other types of zinced conduits give as satisfactory results in most places where corrosive fumes are not present. Hot-dipped-galvanized conduit is, however, more satisfactory where acid fumes are present or where conditions are unusually severe. But even under such severe conditions, ordinary zinced (electro-galvanized or sherardized) conduit, if it is painted with graphite or asphaltum paint, will also prove very satisfactory.

NOTE.—CONDUIT WHICH IS COATED WITH ZINC BY THE ELECTRO-GALVANIZING PROCESS CAN ALWAYS BE DISTINGUISHED from that coated by either of the other two methods. Conduit which is coated by the electro-galvanizing process has only its exterior surface coated with zinc, its interior surface being coated with enamel. The conduit coated by either of the other two methods has both interior and exterior surfaces coated with zinc. The reason for this is that zinc cannot be deposited on the interior surface of a pipe, by the electro-galvanizing process without placing an anode inside of the pipe. Such a procedure would be too expensive due to the great number of anodes required and the high labor cost of carefully setting the pipes in their proper positions.

**20. Enameled Rigid Conduit Is, Generally, Not As Satisfactory As Zinced Rigid Conduit** except under certain favorable conditions. Theoretically, high-grade enamel affords the best possible protection against corrosion, provided that the pipe which is enameled is free from rust and scale before being enameled and that *the enamel remains unbroken* and free from blisters. However, in practice the enamel coating, which is rather brittle, cracks off in places if the conduit is subjected to severe treatment. After the protective enamel coating is cracked off, the pipe will, ordinarily, corrode readily. Enameled rigid conduit has the advantages that its enamel coating is less affected by acids and alkalies than is the zinc coating of galvanized conduit. Enameled conduit has proved entirely satisfactory in dry places where it is not subjected to severe treatment. Thus each has its uses. While gal-

vanized conduit is best adapted to general conditions and most generally used in concrete, nevertheless, black-enameled is useful in dry places where not subjected to severe treatment, and often in places where acid fumes are present; see Div. 12.

NOTE.—ELECTRO-GALVANIZED CONDUIT IS NOT AS SATISFACTORY IN DAMP PLACES AS IS OTHER ZINCED CONDUIT since it has enameled coating on its interior surface. As moisture often collects on the inside of a pipe, the interior surface should be as well protected from corrosion as the exterior surface. However, since the inner surface never receives the severe treatment that the outer surface receives, the enameled inner surface is seldom cracked and so in many installations is very satisfactory.

**21. A Conduit, Which Has Both Its Interior And Exterior Surfaces Covered With First A Zinc Coating And Then An Enamel Coating** (Class 5, Sec. 11), called *Sherarduct*, is now

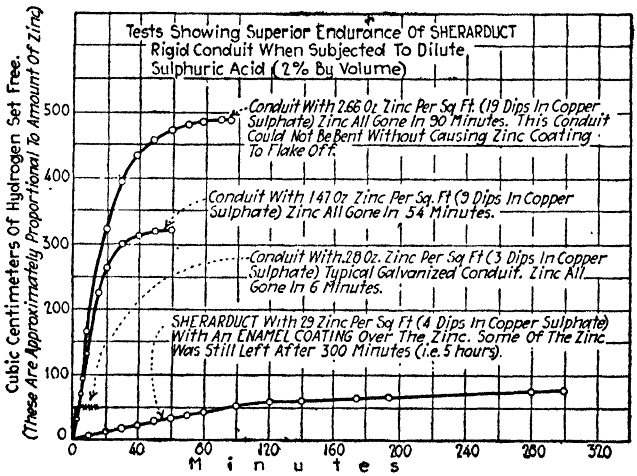


FIG. 1A.—Chart showing the relative effectiveness of several methods of protecting electrical conduits against corrosion.

made by the NATIONAL METAL MOLDING CO. It seems that this conduit has all the advantages of both the galvanized and black-enameled conduits since it has a coating of both zinc and enamel. It should withstand both severe treatment and acid fumes. Figure 1A shows the results of tests made on *Sheraduct* rigid conduit.

**22. A Commercial Line Of Rigid Aluminum Conduit** was recently announced by its manufacturers, the Aluminum

Company of America, Pittsburgh, Pa. This conduit is especially adapted for installation in steam-power plants, locomotive roundhouses and similar places which are subject to corrosive gases. The severe conditions of power-house operation with the attendant moisture and sulphur-bearing gases should be well met by the use of aluminum, a material that is particularly non-corrosive under these conditions. Various expedients have in the past been used to prolong the life of the electrical wiring in the power houses and railroad roundhouses but without much success. Continuity of electric light service in such applications is vital, as an interruption due to deteriorated and exposed wiring may bring disaster with it. Conditions around ash-conveying equipment are particularly severe on electric wiring, and it has been practically impossible to secure more than a few year's life using ordinary steel conduit materials. Aluminum conduit appears to satisfy these exacting conditions. The cost of aluminum conduit is approximately twice that of steel conduit.

NOTE.—ALUMINUM, WHILE RESISTANT TO CORROSION ITSELF, IS FURTHER AUTOMATICALLY PROTECTED BY THE SPONTANEOUS FORMATION OF A THIN FILM OF ALUMINUM OXIDE on the surface of the metal, the oxide being an especially inert substance. This conduit is made from an aluminum alloy containing about 1½ per cent of manganese, giving a hard strong material that may be formed and installed by the ordinary methods applying to other conduit. The specifications, as given by the Board of Underwriters, are followed in the manufacture of this aluminum conduit.

NOTE.—ALUMINUM CONDUIT FITTINGS are now being manufactured. The Aluminum Company of America makes a line as does also The Oliver Electric Co. of Missouri; the fittings made by the concern are especially designed for steam railway roundhouse service.

**23. Conduit Of Brass Or Other Non-Ferrous Alloy Or Metal** is sometimes used, as explained under Sec. 80, to minimize eddy-current effects. Aluminum should also be quite satisfactory in this respect.

**24. Conduit Sizes Are Specified By The Nominal Inside Diameters.**—*Rigid metallic conduit* is made in all standard pipe sizes from ¼ in. to 6 in., nominal inside diameter. The internal and external diameters and the thicknesses of the walls, for the rigid conduit of the various sizes, are the same as those for standard weight pipe of the same sizes. (See folding insert

on the inside of the rear cover for full-size cross-sections, with dimensions, of conduits from ½ in. to 4 in. in size.) Likewise, the same standard sizes of threads are used for rigid conduits of the various sizes as are used for the same sizes of ordinary pipe (see the author's "American Electricians' Handbook" for the sizes of thread used on the various sizes of conduit). Rigid conduit is made in 10-ft. lengths, threaded and reamed on both ends. Each length is furnished with one coupling attached. Sometimes the end without the coupling is fitted with a thread protector. *Flexible conduit* is made in standard pipe sizes from 5⁄16 in. to 2½ in. nominal inside diameter. Its outside diameter is larger than that of the standard pipe of the same size. It is made in 25 to 250-ft. lengths, depending on its size.

NOTE.—CONDUIT SMALLER THAN ½ IN. IN SIZE IS SELDOM USED since it is prohibited by the "National Electric Code" (see author's "Wiring for Light and Power"). Also, since conduit smaller than ½ in. costs the same as ½-in. conduit, there is no reason for using it—except in places where not enough space is available for the ½-in. conduit.

**25. Table Showing Classification of Conduit Cases.** (p. 13). Some of the terms employed in the table are not always used with the same meanings that are given them in the table. The meanings given these terms in the table are probably the most consistent ones that agree with modern practice.

**26. A Conduit Case** (see Table 25) is any metal box-like housing which is inserted in or at the end of a run of conduit to facilitate the manipulating of the conductors, to permit the connection of energy-consuming devices to the conductors, or to contain one or more circuit-controlling or protective devices. *By this definition, any metal box connected in a conduit installation is a conduit case.* It is with this meaning that the term will be used in this book. Thus is made a distinction between a *conduit case* and a *flexible-tubing box,* sometimes called a "*loom*" *box* (one used in knob-and-tube work). In practice, the different conduit cases are generally referred to by special names as "outlet box" or "cabinet" instead of the general name "conduit case."

NOTE.—CONDUIT CASES MUST ALWAYS HAVE METAL (USUALLY STEEL), PORCELAIN, OR OTHER INSULATING NON-COMBUSTIBLE NON-

TABLE 25

| Threading | Classification | Method of Access To Interior | To Make Provision For | Name | Primary Function |
|---|---|---|---|---|---|
| Not Threaded For Conduit | Conduit Boxes | Interior Accessible Only After Removal Of Screws Or Nuts | Energy Consumption | (Energy) Outlet Box | To provide for connection to the wiring system of an energy consuming device, such as wall and ceiling luminaires, wall receptacles, motors, heating devices, etc. |
| | | | Manipulation Of Conductors | Pull Box | To facilitate pulling the conductors into the conduit system. |
| | | | | Junction Box | To house junctions of conductors, where no energy is taken from the wiring system. |
| | | | Switching | Snap Switch (Outlet) Box | To contain only snap switches, one or more. |
| | | | Separation | Separator Box | To support a non-combustible, non-absorptive, insulating wire separator. |
| | | | Controlling | Controller Box | To contain an electric controller. See text for definition of an electric controller. |
| | Conduit Cabinets | Interior Accessible By Opening Hinged Door | Manipulation Of Conductors | Pull Cabinet | Only to facilitate pulling the conductors into the conduit system. |
| | | | Switching | Knife Switch Cabinet | To contain one fused or unfused knife switch. |
| | | | Controlling | Controller Cabinet | To contain an electric controller. See text for definition of an electric controller. |
| | | | Protection And Distribution | Protection Cabinet | To contain the necessary protective devices to protect the set of conductors against a current overload. |
| | | | | Distribution Cabinet | To contain the equipment for distribution (switches, cutouts, or both) of electrical energy to two or more branches, mains, sub mains, or sub feeders. |
| Conduit Fittings; Threaded For Conduit | Screw-Cover Conduit Fittings | Interior Accessible Only After Removal Of Screws | Energy Consumption | (Energy) Outlet Fitting | To provide for connection to the wiring system of an energy consuming device, such as wall and ceiling luminaires, wall and floor receptacles, motors, heating devices, etc. |
| | | | Manipulation Of Conductors | Pull Fitting | Only to facilitate pulling the conductors into the conduit system. |
| | | | | Junction Fitting | Only to house junctions of conductors, where no energy is taken from the wiring system. |
| | | | Switching | Snap Switch (Outlet) Fitting | To contain only snap switches, one or more. |
| | | | Separation | Separator Fitting | To support a non-combustible, non-absorptive insulating wire separator. |
| | Hinged-Cover Conduit Fittings | Interior Accessible By Opening Hinged Door | Switching | Knife Switch Fitting | To contain one fused or unfused knife switch. |
| | | | Distribution And Protection | Protection Fitting | To contain the necessary protective devices to protect the set of conductors against a current overload. |
| | | | | Distribution Fitting | To contain the equipment for distribution (switches, cutouts, or both) of electrical energy to two or more branches, mains, sub-mains or sub-feeders.' |

ABSORPTIVE COVERS. These covers may be hinged, screwed on to the cases, or fastened in any other way so that they can be removed or opened. A canopy supported by a lighting fixture sometimes serves as a cover. In some types of conduit cases a flush wall plate forms the cover (Sec. 49).

**27. The Various Functions Of Conduit Cases Of The Different Types** are tabulated in the last column of Table 25. A conduit case may be used to serve two or more of these functions. Thus, it frequently occurs that an energy outlet box (Sec. 34 and Table 25) is used also to house other con-

nections than those of the tap circuit which feeds directly from the outlet and to facilitate the pulling in of the conductors. An outlet box thus used would therefore serve also as a pull box and a junction box. However, since the primary purpose of the box is, in such a case, to serve as an outlet box, it would be so termed. With the exception of the separator box or fitting, the "National Electrical Code" requires that all conduit cases (Table 25) be so installed that they are accessible without disturbing the structure of the building. Furthermore, the "Code" requires that all conduit cases be made of a "good-conductor" material which is securely connected, both mechanically and electrically, to the conduit system.

NOTE.—A SEPARATOR BOX OR FITTING NEED NOT BE ACCESSIBLE ("National Electrical Code") if the conductors are brought out of the conduit system without "splice, joint, or tap."

**28. A Conduit Box** (Table 25 and Figs. 2 and 3) is a conduit case to which conduit is or can be secured by means of conduit

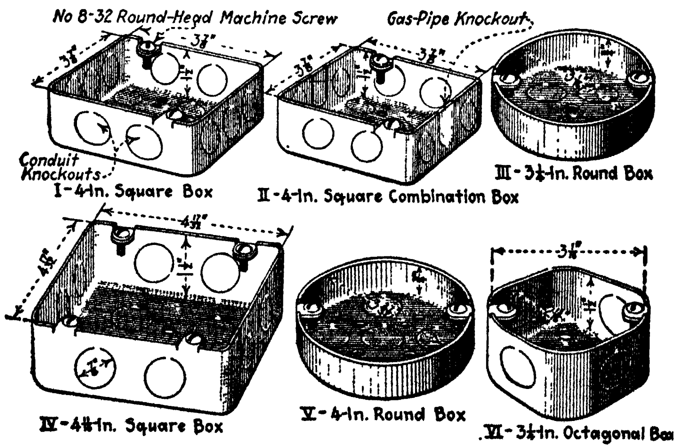


FIG. 2.—Standard pressed-steel conduit boxes. The dimensions of boxes may vary $\frac{1}{16}$ in. from those given. (The 4-in. octagonal boxes, not shown, are $3\frac{1}{2}$ in. across flats and $3\frac{27}{32}$ in. in diameter, inside dimensions.)

accessories (Sec. 57), and which is provided with a cover that is held in place by screws or nuts. The conduit box always has knockouts, or the equivalent, formed by drilled holes. It may be used to serve various purposes, as shown in the right-hand column in Table 25.

Note.—Conduit Boxes Are Sometimes Called Outlet Boxes (Sec. 43). In the past, the term "outlet box" was used to designate all conduit boxes. It had the same meaning as the term "conduit box" has

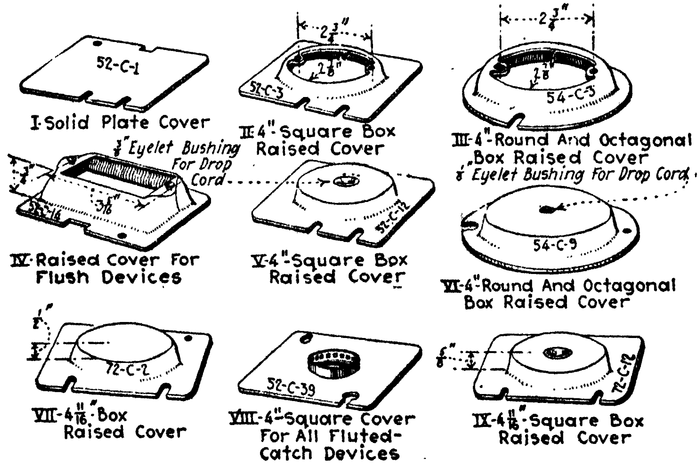


Fig. 3.—A few conduit box covers. (The raised covers may be had in other heights besides those shown.)

in this book. Now, the tendency is to restrict the term "outlet box" to mean only a box which is used at an outlet (Sec. 31).

**29. A Conduit Cabinet** (Table 25 and Fig. 4) is conduit case which is provided with a hinged door and with knockouts—or the equivalent in drilled holes—designed for fastening the cabinet to the conduit by means of conduit accessories (Sec. 57). The distinguishing characteristic between conduit cabinets and boxes is that the cabinets have hinged doors whereas the boxes have covers which are held in place by screws or nuts and which must be unscrewed to gain access to the interior of the box. Incidentally, cabinets are ordinarily larger than boxes, though not necessarily so.

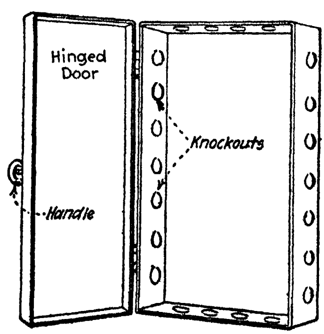


Fig. 4.—Standard surface-type steel cabinet or panel box.

Note.—The Accessories Which Are Generally Used To Fasten Conduit To Boxes Or Cabinets are nipples, "box connectors," locknuts, and bushings.

**30. A Conduit Fitting Or Body** (Fig. 5) is a conduit case which is provided with projections, which have female pipe threads, whereby the conduit may be screwed directly to the fitting. As indicated in Table 25, some conduit fittings are

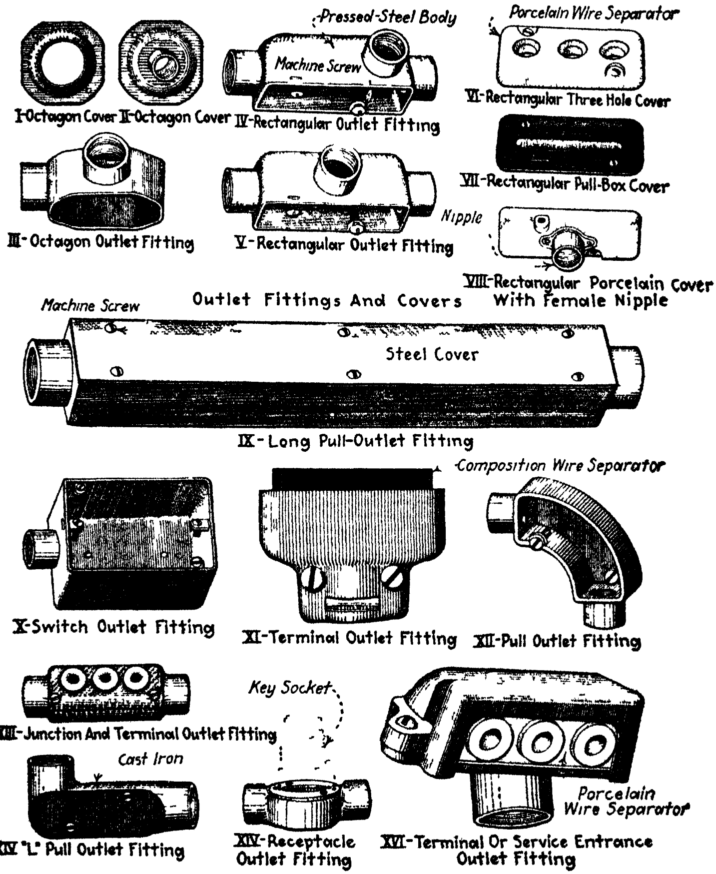


FIG. 5.—Some of the more common types of conduit fittings and covers. Some fittings are made of cast iron while others are made of pressed steel.

made with covers which are fastened to the body with screws; others are provided with hinged covers, or doors. The principal distinguishing difference between a fitting and a box or cabinet is in the method of attaching the conduit. As indicated in Table 25, the functions of fittings, boxes, and

cabinets are essentially the same. Boxes are practically always used in concealed work; fittings (floor fittings, Sec. 48 excepted) are seldom used in concealed work. Both boxes and fittings are used in open work. Whether or not a conduit case should have a cover held with screws (box or screw-cover fitting), or a hinged cover (cabinet or hinged-cover fitting) depends upon the service which it is to perform. That is, if a conduit case is to be used to contain a cutout it should have a hinged door so that the interior of the box may be readily accessible for fuse replacement. If a conduit case is to house the junction of conductors, such ready access is neither necessary nor desirable.

NOTE.—MOST MANUFACTURERS CALL THEIR CONDUIT FITTINGS by special trade names. Some of these names are "Condulets," Unilets," "Pipe Taplets," and "V.V. Fittings." See also Sec. 55.

**31. An Electric Outlet** (usually designated merely as an *outlet*) is a location on a branch circuit of any *wiring system* at which access to the conductors is intentionally provided for the purpose of connecting energy-consuming switching or control devices.

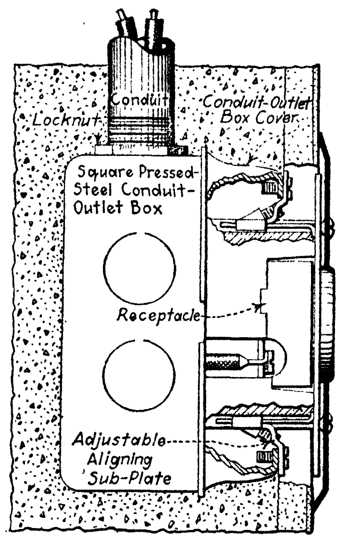


FIG. 6.—Showing a square pressed-steel conduit box used as a receptacle outlet box. This box contains a receptacle having an adjustable aligning sub-plate. (Receptacle manufactured by *Harvey Hubbell, Inc., Bridgeport, Conn.*)

NOTE.—THE "WIRING SYSTEM" comprises the conduit, boxes, cabinets and wire but it does not include the luminaires (fixtures) motors or other energy-consuming devices or the wiring included in these devices.

NOTE.—A BRANCH CIRCUIT (as defined in the "*National Electrical Code*") is that portion of a wiring system which extends beyond the final set of fuses or circuit breakers which protect it, and at points on which energy is taken to supply fixtures, lamps, heaters, motors and current-consuming devices generally; such points are designated as "outlets."

**32. An Outlet Box Or Fitting** See energy outlet box (Fig. 6) and snap-switch outlet box (Fig. 18 and Table 25) is a conduit

box or fitting which is installed in an electric wiring system at an electric outlet. A floor fitting often called a "floor box" is one form of energy outlet fitting. It is probably the only one which is frequently used in concealed conduit work.

**33. An Energy Outlet** is an electric outlet which is provided for the attachment of an energy-consuming device or devices.

**34. An Energy Outlet Box Or Fitting** is an outlet box or fitting which is installed at an energy outlet.

**35. A Snap-Switch Box Or Fitting** (Table 25 and Figs. 2, 3, 5 and 18) is a conduit box or a conduit fitting which only contains one or more snap switches. It is often called a "switch outlet box." In this text it is classed as an outlet box, Sec. 32. Sometimes only energy outlet boxes are considered as outlet boxes and the snap-switch box is not so considered.

**36. A Pull Box, Cabinet, Or Body Fitting** (Table 25 and Figs. 2, 3, 5 and 19) is a conduit box cabinet, or fitting, which is installed only for the convenience of pulling in the conductors. All conduit cases, to a certain extent, facilitate the pulling in of the conductors, but only those cases which are used solely for the pulling in of the conductors are called *pull cases.*

**37. A Junction Box, Or Fitting** (Table 25 and Figs. 2, 3, 5 and 19) is a conduit box or fitting (from which no energy is taken from the wiring system) for housing the unfused junction or connection of conductors. Whenever the sizes of the conductors forming a junction are the same (since no fuses or cutouts are required), the one set of conductors may be soldered directly to the conductors which feed them and a junction box or fitting may be used. Junctions in concealed conduit installations are generally made in accessible outlet boxes which are also serving other purposes (Sec. 31).

**38. A Separator Box Or Fitting** (Table 25 and Fig. 5) is a conduit box or fitting which is provided with a non-combustible, non-absorptive, insulating cover with separate bushed holes through which the conductors are brought out of the conduit. Separator boxes or fittings are employed only at points where a system of wiring changes from the conduit method to either the open or the wooden-moulding method. Separator boxes need not be accessible (Sec. 27).

**39. A Controller Box Or Cabinet** is a conduit box or cabinet which contains an electric controller. A "controller" is defined as a device or devices to control in some predetermined manner the electric power delivered to the device governed.

**40. A Knife-Switch Cabinet Or Fitting** (Table 25 and Fig. 24) is a conduit cabinet or fitting which contains only one fused or unfused knife switch.

**41. A Protection Cabinet Or Fitting** (Table 25 and Fig. 477) is a conduit cabinet or fitting which contains only the necessary protective device or devices to protect one set of conductors, that is, a set of fuses, relays, or an overload circuit breaker.

**42. A Distribution Cabinet Or Fitting** (Table 25 and Fig. 22) is a conduit cabinet or fitting which contains the equipment—busbars, fuses, and sometimes switches—for distribution of electrical energy to one or more branches, mains, sub-mains, or sub-feeders.

**43. Conduit Boxes (Table 25) Are Made In Various Types And Shapes** each of which is adapted for certain purposes.

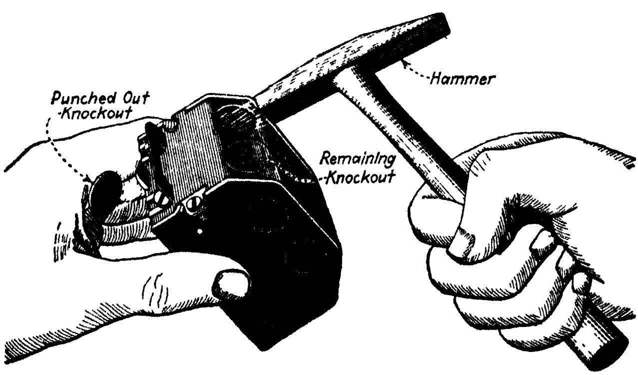


Fig. 7.—Showing how a "knockout" is removed from a box with a hammer blow.

The types of conduit boxes most generally used are the pressed-steel boxes shown in Fig. 2. They are known as round, square, or octagonal boxes depending on their shapes. Since these types of boxes are so frequently used at outlets, they are sometimes called in the trade simply by the general term, "outlet boxes." The round, square, and octagonal boxes are pressed or stamped-steel boxes which have *knockouts* (Fig. 7) and

which can be used to perform various functions by using different covers on the same box. That is, with proper covers (see Fig. 3) they may serve as outlet, pull, junction, or separator boxes. The square boxes are generally used in walls to serve as switch, receptacle (Fig. 6), receiver, or junction boxes. The round and octagonal boxes are generally used in ceilings and (sometimes in walls) as energy outlet, pull, or junction boxes. Since the octagonal box is preferable to the round box, as it offers a flat surface of the locknut to bear against, the manufacture of the round boxes 1½ and 2½ in. deep, with knockouts in the sides, has been discontinued. However, the round boxes are still made in the shallow depths with no knockouts provided in the sides.

NOTE.—THE SIZES OF THE ROUND, SQUARE, AND OCTAGONAL BOXES are standardized so that the boxes of different manufacturers are interchangeable. The round and octagonal boxes are made in sizes of the same diameter and the same covers fit them. They are made in two sizes: one, 3¼ in. in diameter and the other, 4 in. in diameter. The 4-in. diameter octagonal box is made in two depths; one is 1½ in. deep on the inside and the other is 2⅛ in. deep on the inside. The 3¼-in. diameter octagonal box is made in only the 1½-in. depth. The round 3¼ and 4-in. boxes are made only in "shallow" form with depths of ½ and ¾ in. The square boxes are made in two sizes, one with 4-in. sides and the other with 4¹¹⁄₁₆-in. sides. The 4¹¹⁄₁₆-in. square boxes are made 1½ and 2⅛ in. deep whereas the 4-in. square boxes are made only in the 1½-in. depth. The knockouts are generally arranged as shown in Fig. 2.

NOTE.—CONDUIT (OUTLET) PLATES ARE SOMETIMES USED instead of conduit (outlet) boxes. These are merely flat sheet-steel discs having knockout holes punched in them. They have no sides. These outlet plates, however, can only be used at fixture outlets where the canopy of the fixture provides a metallic covering over the wire splices. The use of plates, even with fixtures, is being discouraged (see following Sec. 44) since the new fixtures which have flat canopies cannot be used over them because the flat canopies do not provide sufficient room for the splices.

NOTE.—SCREW TAPPINGS FOR STANDARD CONDUIT BOXES AND CONDUIT BOX COVERS are as follows: The standard boxes are tapped for 8–32 screws which are used to fasten the covers to the boxes. The *box covers* are not tapped for these screws but simply contain a large plain hole or a slot to admit them. The canopy and *Elexit box covers* are tapped for two 8–32 screws with which wiring devices, such as exposed receptacles, and Elexit receptacles are fastened to the covers. The *switch box covers* are tapped for 6–32 screws, since this size of screw is provided with the flush switches and receptacles for their attachment to the conduit box covers. The coverless switch boxes, such as the sectional switch

box (Fig. 18), are also tapped for 6–32 screws to permit attachment of the flush switches and receptacles.

**44. A Chart Of Standardized Lighting Fixture Outlet Boxes** (Figs. 8, 9, 10, 11, 12, and 13) has been prepared by the *New*

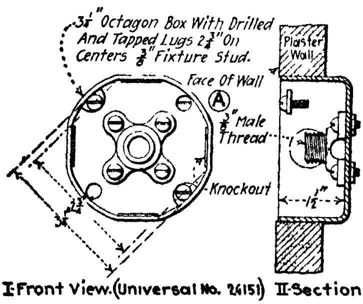


Fig. 8.—Type *A* outlet. Deep box without cover for utilitarian work. "This octagonal box recommended for ordinary fixture work and especially convenient for all types of inexpensive one-light receptacles in walls and ceilings of closets and service department." It is made by the following manufacturers: *Adapti Mfg Co., Appleton Electric Co., Chicago Fuse Mfg. Co., Michigan Stamping Co., National Metal Moulding Co., Sprague Electric Works, Steel City Electric Co., The Pratt Church Co., and Thomas & Betts.*

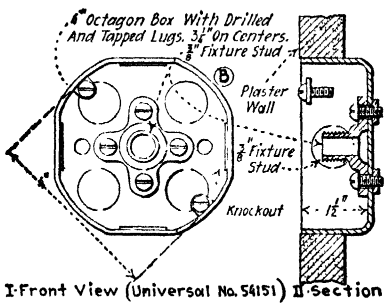


Fig. 9.

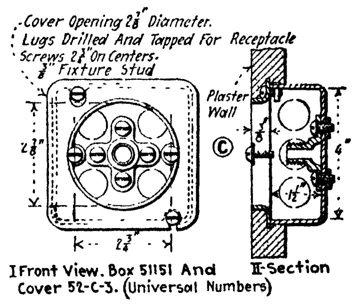


Fig. 10.

Fig. 9.—Type *B* outlet. The octagonal box recommended for ordinary fixture work when Type *A* outlet is not large enough to accommodate a large number of wires or when hanger for heavy fixture will be used. Drilled and tapped lugs accommodate inexpensive one-light receptacles. Made by same manufacturers as Type *A*.

Fig. 10.—Type *C* outlet. This outlet box recommended for all ordinary fixtures outlets. Ample space in box for gas pipe or several conduits, or the necessary wire splices. Receptacles can be attached to cover. Made by same manufacturers as Type *A*.

*York Division of Lighting-Fixture Manufacturers.* This chart has been distributed among electrical engineers, contractors, and architects to enable them to specify and use outlet boxes

which will permit the installation of better fixtures on safe outlets. In the past, the New York lighting-fixture manufacturers have been hampered by its not being possible for them to furnish certain types of lighting fixtures (which were selected and desired) because of outlet boxes of the wrong type having been installed by the electrical contractor. If the recommendations of the chart are followed, this difficulty will disappear. Outlet boxes of the "shallow" type (Fig. 13) are

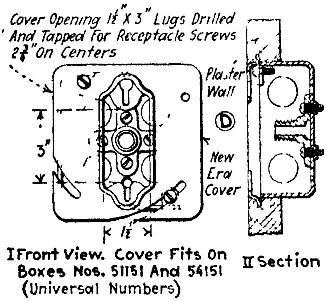


FIG 11.

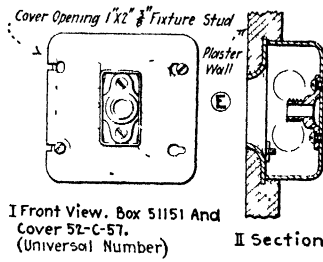


FIG. 12.

FIG. 11.—Type *D* outlet. This outlet box recommended for bracket outlets particularly in rooms where architectural style will be a consideration. Accommodates very-flat or narrow backplates on period fixtures. Box made by the same manufacturer as Type *A*. "New Era" cover distributed by *R. B. Corey & Co., New York, N. Y.*

FIG. 12—Type *E* outlet. This outlet box recommended for bracket outlets only in rooms where architectural style will be a consideration. Accommodates very-narrow backplates less than 1½ in. in width. Box made by same manufacturer as Type *A*. Cover made by the *Pratt Chuck Co.* and *Thomas & Betts Co.*

particularly condemned because they do not permit the installation of fixtures which have flat or shallow backplates (canopies). The chart recommends:

"*An approved galvanized-iron or steel outlet box*, as hereinafter specified (for conduit, flexible armored cable or knob-and-tube wiring) shall be installed at each outlet taking lighting fixtures as shown on plans."

"*At all ceiling outlets* there shall be used an octagonal outlet box of not less than 3 in. in diameter and not more than 4 in. in diameter, both approximately 1½ in. deep with cover on, same having 3-in. diameter round opening. Said cover to have lugs. (Select types *A*, *B*, or *C* from Figs. 8, 9, 10, and give manufacturers' names and numbers.)"

"*At all bracket outlets in service portion of house*, garage, cellar, and attic, there shall be used an octagonal outlet box 3 in. in diameter, approximately 1½ in. deep, with drilled and tapped lugs, 2¾ in. on centers. (Type *A*, Fig. 12.)"

"*At all bracket outlets in master's living and sleeping quarters,* there shall be used a 4-in. square outlet box approximately 1½ in. deep with cover. (Here specify type of cover desired according to style of fixtures to be used, selecting from types *C*, Fig. 10; *D*, Fig. 11; or *E*, Fig. 12.)"

"*All covers of boxes* shall be galvanized and shall be rigidly fastened to boxes by not less than two screws."

"*In each outlet box there shall be a fixture stud* with ⅜-in. male thread, which stud shall be rigidly fastened in box by not less than four (4) bolts."

"*In setting all outlet boxes,* extra precaution shall be taken that same are securely fastened in the wall, set true and plumb, and that NO PART OF THE BOX OR COVER EXTENDS BEYOND THE FINISHED PLASTER OR TRIM. Contractor shall be obliged at his expense to reset any boxes not installed in accordance with this specification."

"*Under no circumstances shall a cast or stamped shallow-type 'box' or 'surface plate' be used.* (One of this class is shown in type *NG*, Fig. 13 )"

"*The wires at all outlets which are controlled by switches* shall be properly tagged for identification, and branch runs spliced up ready to receive lighting fixtures."

"*The contractor will be obliged, at his expense, to reset any outlet boxes* where it is the opinion of the architect that the type or style of lighting fixture to be hung cannot be used owing to the interference of sprinkler, steam, water pipes, ducts, etc. or where boxes have been placed too close to doors, window trim, medicine closets, or plate shelves, etc."

"*Note No. 1.—It is further suggested that, where the use of a heavy ceiling fixture is contemplated,* the electrical contractor be instructed to do away with the ordinary fixture stud in outlet box and supply in its place a suitable and substantial iron pipe hanger with at least a ½-in. iron pipe thread on same. Style of hanger to be approved by the architect."

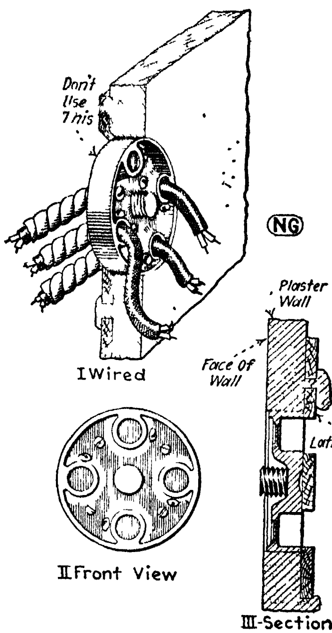


FIG. 13.—Type *NG* outlet box which is made in various types in cast iron or stamped steel. This outlet, known as the *shallow-type flexible armored-cable box*, is not recommended. As evident, from *I* above, this box is not capable of housing the spliced joints of wires and always requires deep and objectionable canopies on fixtures. Shallow and oval fixture-backplates cannot be used.

"*Note No. 2.—It is also suggested that where the local board of Fire Underwriters having jurisdiction will approve "polarization"* that the electrical contractor be instructed to install a polarized system of wiring which will

permit all straight electric lighting fixtures to be installed without *insulating joints*, which means a saving of expense and the use of better type of lighting fixtures, which otherwise would have to be eliminated, were insulating joints and canopy fibers necessary."

**45. Standard Catalogue Numbers Called "Universal Numbers" For The Square, Round, And Octagonal Pressed-Steel Conduit Boxes And Covers** have been adopted. A standard or universal catalogue number denotes a certain definite box or cover. It applies to this same box or cover as made by every manufacturer. The boxes and covers made by different manufacturers are almost identical, so it makes little difference, insofar as dimensions are concerned, which manufacturer's boxes and covers are used. In the past, the use of individual manufacturers' catalogue numbers led to confusion when boxes or covers were ordered by one manufacturer's number and the order filled with boxes or covers made by another manufacturer. The use of the universal number, which denotes a definite box or cover, regardless of who manufacturers it, eliminates this confusion. In the universal numbering system, the box numbers consist entirely of numerals, while the cover numbers have a letter "C" after the first two numerals. The numbering system is so designed that: *the first two numerals of the cover for a certain size and shape of box will be the same as the first two numerals of the box itself* (see Fig. 14), except for the round shallow boxes which take the same cover as the corresponding size of octagonal box.

EXAMPLE.—The universal catalogue number for a $4^{11}/_{16}$-in. square box, $1\frac{1}{2}$ in. deep (Fig. 14) is "72,151." Hence, according to the universal numbering system, any cover with a number beginning with "72C," as for example "72-C-39," will fit this square box (No. 72,151). Also, since the universal number for the $4^{11}/_{16}$-in. square box, $2\frac{1}{8}$ in. deep is "72,171," the same cover (No. "72-C-39") will likewise fit this box.

NOTE.—THE BASIS OF THE SYSTEM OF "UNIVERSAL NUMBERS" is given in the following tabulation:

BOXES

| No. | Position of figure in the number and what it designates | | | | |
|---|---|---|---|---|---|
| | First position LARGEST DIAM. (nearest below) inches | Second position, SHAPE | Third position, TYPE BOX | Fourth POSITION, INSIDE DEPTH (nearest below) inches | Fifth POSITION, KNOCKOUTS AND EARS |
| 1 | 3 | Square (Comb ) | Outlet (concealed). | 1/2 | Conduit with ears. |
| 2 | 3 1/4 | Sq. (Str. electric). | Outlet (exposed). | 3/4 | Conduit without ears. |
| 3 | 3 1/2 | Sq. extension ring. | *Flush device (concealed). | 1 | Loom with ears. |
| 4 | 3 3/4 | Octagonal. | *Flush device (exposed). | 1 1/4 | Loom without ears. |
| 5 | 4 | Octagonal extension ring. | Concrete. | 1 1/2 | Comb. with ears. |
| 6 | 4 1/4 | Round. | Ceiling with Arm. Cond Clamp. | 1 3/4 | Comb. without ears. |
| 7 | 4 1/2 | Round extension ring. | †Plates. | 2 | |
| 8 | 5 | Rectangular. | ............ | 2 1/2 | |
| 9 | 6 and + | ............ | ............ | 2 1/2 + | |

*This key does not cover "Flush switch boxes" or "Wall cases "
†"Plates"—definition: Flat or flanged disc of 0.080 in. thick metal with knockouts for conduits.

The *covers* and *plate covers* have the first two figures in the Universal number the same as the corresponding box number. In the third number position, the covers have the letter "C" and the cover plates have the letter "R" to differentiate them from the box numbers. The fourth and fifth figures refer to the style of cover and its use.

Thus from the above tabulation, the number of any type of box can be determined.

EXAMPLE.—A 4-in. octagonal, concealed work outlet box 1 1/2 in. deep, provided with conduit knockouts and ears, would be number 54,151. This can be obtained from the tabulation as follows: First figure, 5, signifies a 4-in. box; the second figure, 4, an octagonal shape; the third figure, 1, a concealed outlet box; the fourth figure, 5, a 1 1/2 in. depth; and the fifth, figure, 1, signifies that the box is provided with conduit knockouts and ears.

**46. A Key, Called The "Universal Key," For Matching Wiring Devices, Pressed-Steel Boxes, And Covers** has been developed by the Sprague Electric Works of the General

Electric Company. This key consists of a folding cover enclosing a 70-page booklet. It is furnished gratis upon request. There is reproduced in Fig. 14, for illustration, a portion of the inside of the left-hand cover and also a portion of page 40 of the booklet. This left-hand cover and portion of the booklet comprises the left half of the complete key when it is opened out. On the inside of the right-hand cover (not shown here) are given the new catalogue numbers and the key symbols of the $3\frac{1}{4}$-in. octagon pressed-steel box and covers and of the new type shallow and deep conduit boxes and covers. The "Universal Key" eliminates the former necessity of looking through various catalogues for a pressed-steel box and cover that will accommodate a certain device and also the uncertainty that the boxes and covers chosen may not fit the device. In the booklet, the catalogue numbers of the wiring devices of various manufacturers (fifteen in all) are listed opposite the symbols of the boxes and covers which will accommodate the devices. The symbols refer to the illustrations on the insides of the covers and designate exactly what boxes and covers may be used for a certain device.

Example.—It has been decided to use the General Electric Company's device, catalogue number 39,236, find the box and cover which can be used with this device. Solution.—First turn to the page on which is listed, in its left-hand column, the General Electric Co.'s device number 39,236. This is found to be page 40, as shown in Fig. 14A. In the middle column, under the heading "Boxes," on the same line with catalogue number "39,236," will be found six key symbols, each of which refers to a box which will fit the specified device. The symbol "2A," by reference to the left-hand flyleaf, refers to a 4-in. square box, new catalogue or Universal number "51,151"; symbol "3A" refers to a 4-in. octagonal box of two different depths, etc. Covers to fit are taken from the symbols in the right-hand column of the page marked "Covers." The symbol "2D" refers to a cover which has a new catalogue number "52,028," etc. If box 2A is used cover 2D must be used, the cover numeral corresponding to that of the box which it fits.

**47. A Two-Piece Round Or Octagonal Pressed-Steel Conduit Box** (Fig. 15). **Is Used Very Extensively In Concrete Work** as a concrete box. It is generally known as a *concrete box*. These boxes are made of pressed steel covered with a coat of zinc. The back of the box is fastened to the box body with screws. In installing the boxes on concrete forms, the box

| Cat No. | 4-11/16" Square | |
|---|---|---|
| 72151 | 1½" Deep | 1A |
| 72171 | 2⅛" Deep | 1A |
| 72C3 | Canopy 2¾" S.C. | 1C |
| 72C39 | Fluted Catch | 1J |
| | **4" Square** | |
| 51151 | Comb. Gas Pipe & Str. Elec 1½" Deep | 2A |
| 53151 | Ext Ring 1½" Deep | 2A |
| 51C5 | Canopy 2¾" S C | 2C |
| 52C3 | Canopy 2¾" S C | 2C |
| 52C28 | S C from ⅞" to 1⅞" | 2D |
| 52C44 | Federal | 2E |
| 52C35 | Screw Ring Receptacle | 2F |
| 52C36 | 5 Notch Recept | 2G |
| 52C39 | Fluted Catch | 2J |
| 52C13 | ½" Deep Flush Recept | 2K |
| 52C14 | ¾" Deep Flush Recept | 2K |
| 52C15 | 1" Deep Flush Recept. | 2K |
| 52C17 | ½" Deep Flush Recept. | 2K |
| 52C18 | ¾" Deep Flush Recept. | 2K |

| Cat. No. | 4" Octagon | |
|---|---|---|
| 54151 | 1½" Deep | 3A |
| 54171 | 2⅛" Deep | 3A |
| 54155 | 1½" Deep | 3A |
| 55151 | Ext Ring 1½" Deep | 3A |
| 55171 | Ext Ring 2⅛" Deep | 3A |
| 56111 | ½" Deep | 3B |
| 56115 | ½" Deep | 3B |
| 56121 | ¾" Deep | 3B |
| 56125 | ¾" Deep | 3B |
| 54C3 | Canopy 2¾" S C | 3C |
| 54C28 | S C from ⅞" to 1⅞" | 3D |
| 54C44 | Federal | 3E |
| 54C35 | Screw Ring Recept | 3F |
| 54C36 | 5 Notch Recept. | 3G |
| 54C49 | Benjamin 2-Screw Recept. | 3H |
| 54C33 | Std AMES 2-Screw Recept | 3I |
| 54C39 | Fluted Catch | 3J |
| 54C37 | Hubbel Floor Recept. | 3L |
| 54C54 | Snap Switches 2⅛" Opening | 3M |
| 54C53 | S C— 2⅛" 2¼" 2⅜" | 3N |

| | |
|---|---|
| Sprague | 1-10&65-72 |
| Arrow Elec. | 12-22 |
| Benjamin | 22 |
| Bryant | 23-33 |
| Chelton | 33 |
| C-H | 34 |
| Diamond H | 34-35 |
| Federal | 38 |
| Freeman | 38-39 |
| G. F | 40-44 |
| H. & H. | 45-53 |
| Hubbell | 54-56 |
| Manhattan | 57 |
| P. & S. | 57-62 |
| Trumbull | 63-64 |
| Sprague | 1-10&65-72 |

FIG. 14.—Reproduction of a portion of the "Universal key" developed and distributed by the *Sprague Electric Works.*

GENERAL ELECTRIC CO.

| Cat. No. | Boxes | Covers |
|---|---|---|
| 9184 | 2A-3A-3B-4A-4B-5A | 2D-3D-4D-5D |
| 9185 | 2A-3A-3B-4A-4B-5A | 2D-3D-4D-5D |
| 28856 | 2A-3A-3B-4A-4B-5A | 2D-3D-4D-5D |
| 33559 | 2A-3A-3B-4A-4B-5A | 2D-3D-4D-5D |
| 36817 | 2A-6A | 2K-60 |
| 39236 | 2A-3A-3B-4A-4B-5A | 2D-3D-4D-5D |
| 39237 | 2A-3A-3B-4A-4B-5A | 2D-3D-4D-5D |
| 40496 | 2A-3A-3B-4A-4B-5A | 2D-3D-4D-5D |
| 49355 | 2A-3A-3B-4A-4B-5A | 2D-3D-4D-5D |
| 50717 | 2A-3A-3B-4A-4B-5A | 2D-3D-4D-5D |
| 50745 | 2A-3A-3B-4A-4B-5A | 2D-3D-4D-5D |
| 50746 | 2A-3A-3B-4A-4B-5A | 2D-3D-4D-5D |
| 50753 | 2A-3A-3B-4A-4B-5A | 2D-3D-4D-5D |
| 50755 | 2A-3A-3B-4A-4B-5A | 2D-3D-4D-5D |
| 50786 | 2A-3A-3B-4A-4B-5A | 2D-3D-4D-5D |
| 50797 | 2A-3A-3B-4A-4B-5A | 2D-3D-4D-5D |
| 50798 | 2A-3A-3B-4A-4B-5A | 2D-3D-4D-5D |
| 59807 | 2A-3A-3B-4A-4B-5A | 2D-3D-4D-5D |
| 59873 | 2A-3A-3B-4A-4B-5A | 2D-3D-4D-5D |
| 59874 | 2A-3A-3B-4A-4B-5A | 2D-3D-4D-5D |
| 59875 | 2A-3A-3B-4A-4B-5A | 2D-3D-4D-5D |
| 60018 | 2A-3A-3B-4A-4B-5A | 2D-3D-4D-5D |
| 60019 | 2A-3A-3B-4A-4B-5A | 2D-3D-4D-5D |
| 60020 | 2A-3A-3B-4A-4B-5A | 2D-3D-4D-5D |
| 60124 | 2A-3A-3B-4A-4B-5A | 2D-3D-4D-5D |
| 60294 | 2A-3A-3B-4A-4B-5A | 2D-3D-4D-5D |
| 60295 | 2A-3A-3B-4A-4B-5A | 2D-3D-4D-5D |
| 60296 | 2A-3A-3B-4A-4B-5A | 2D-3D-4D-5D |
| 60447 | 2A-3A-3B-4A-4B-5A | 2D-3D-3M-4D-5D |
| 60448 | 2A-3A-3B-4A-4B-5A | 2D-3D-3M-4D-5D |
| 60449 | 2A-3A-3B-4A-4B-5A | 2D-3D-3M-4D-5D |
| 60450 | 2A-3A-3B-4A-4B-5A | 2D-3D-3M-4D-5D |
| 60451 | 2A-3A-3B-4A-4B-5A | 2D-3D-3M-4D-5D |
| 60452 | 2A-3A-3B-4A-4B-5A | 2D-3D-3M-4D-5D |
| 60453 | 2A-3A-3B-4A-4B-5A | 2D-3D-3M-4D-5D |
| 60454 | 2A-3A-3B-4A-4B-5A | 2D-3D-3M-4D-5D |
| 60455 | 2A-3A-3B-4A-4B-5A | 2D-3D-3M-4D-5D |
| 60456 | 2A-3A-3B-4A-4B-5A | 2D-3D-3M-4D-5D |
| 60458 | 2A-3A-3B-4A-4B-5A | 2D-3D-3M-4D-5D |
| 60459 | 2A-3A-3B-4A-4B-5A | 2D-3D-3M-4D-5D |
| 60460 | 2A-3A-3B-4A-4B-5A | 2D-3D-3M-4D-5D |
| 60461 | 2A-3A-3B-4A-4B-5A | 2D-3D-3M-4D-5D |
| 60462 | 2A-3A-3B-4A-4B-5A | 2D-3D-3M-4D-5D |
| 60463 | 2A-3A-3B-4A-4B-5A | 2D-3D-3M-4D-5D |
| 60464 | 2A-3A-3B-4A-4B-5A | 2D-3D-3M-4D-5D |
| 60465 | 2A-3A-3B-4A-4B-5A | 2D-3D-3M-4D-5D |
| 60466 | 2A-3A-3B-4A-4B-5A | 2D-3D-3M-4D-5D |
| 60467 | 2A-3A-3B-4A-4B-5A | 2D-3D-3M-4D-5D |
| 60468 | 2A-6A | 2K-6M |
| 60469 | 2A-6A | 2K-6M |
| 60470 | 2A-6A | 2K-6M |
| 60473 | 2A-6A | 2K-6M |
| 60475 | 2A-6A | 2K-6M |
| 60476 | 2A-6A | 2K-6M |
| 60477 | 2A-6A | 2K-6M |
| 60478 | 2A-6A | 2K-6M |
| 60479 | 2A-6A | 2K-6M |
| 60480 | 2A-6A | 2K-6M |
| 60931 | 3A-4A-5A | 3I-4I-5I |
| 60938 | 2A-3A-3B-4A-4B-5A | 2D-3D-4D-5D |
| 60939 | 2A-3A-3B-4A-4B-5A | 2D-3D-4D-5D |
| 60950 | 2A-3A-3B-4A-4B-5A | 2D-3D-4D-5D |
| 60951 | 2A-3A-3B-4A-4B-5A | 2D-3D-4D-5D |
| 60952 | 2A-3A-3B-4A-4B-5A | 2D-3D-4D-5D |
| 60953 | 2A-3A-3B-4A-4B-5A | 2D-3D-4D-5D |
| 60954 | 2A-3A-3B-4A-4B-5A | 2D-3D-4D-5D |
| 60955 | 2A-3A-3B-4A-4B-5A | 2D-3D-4D-5D |
| 62357 | 1A-2A-3A-4A | 1C-2C-3C |
| 62410 | 2A-3A-3B-4A-4B-5A | 2D-3D-4D-5D |
| 62411 | 2A-3A-3B-4A-4B-5A | 2D-3D-4D-5D |
| 62412 | 2A-3A-3B-4A-4B-5A | 2D-3D-4D-5D |
| 62553 | 2A-3A-3B-4A-4B-5A | 2D-3D-4D-5D |
| 62554 | 2A-3A-3B-4A-4B-5A | 2D-3D-4D-5D |
| 62555 | 2A-3A-3B-4A-4B-5A | 2D-3D-4D-5D |
| 62556 | 2A-3A-3B-4A-4B-5A | 2D-3D-4D-5D |

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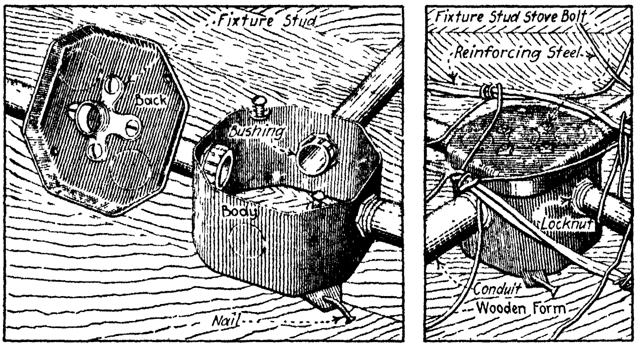
FIG. 14A.—Page 40 of the "Universal Key."

portions, with backs removed, are nailed to the wooden forms and the conduits are then attached (Fig. 15-*I*). Fixture studs can be attached to the backs of the boxes in the usual manner




I-Concrete Box With Back Removed  II Concrete Box With Back Attached

FIG. 15.—Concrete box made by *National Metal Moulding Co., Pittsburgh, Pa.* In *I* the back is removed to permit the "making up" of the conduits into the box body. In *II* the box is shown in position with the concrete-reinforcing steel in place, ready for the pouring of the concrete.

After the conduits have been "made up" into the box portions, the backs are then fastened into place by means of screws (Fig. 15-*II*). The use of this box saves time in installing. It will be readily noted that where it is used the electrician does not have to reach in under the box to fasten the conduit locknut and bushings—as he would have to do with a box which has a non-removable back. The boxes are 4 in. in diameter and are made in several depths.

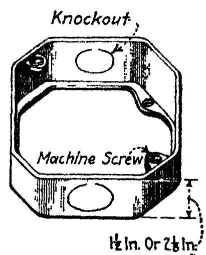



FIG. 16.—A pressed-steel extension ring for an octagonal box. These rings are made for octagonal and quare boxes. (*Chicago Fuse Mfg. Co., Chicago, Ill.*)

NOTE.—EXTENSION RINGS (Fig. 16) together with conduit boxes may be used as concrete boxes. By means of extension rings conduit boxes may be made as deep as desired. Extension rings are made for the 4-in. standard pressed-steel square and octagonal boxes. These extension rings are made in depths of 1½ and 2⅛ in. for the octagonal box and 1½ in. deep for the square box. Thus if a 2⅛-in. extension ring is used with a 2⅛-in. box, there results the equivalent of a box 4¼ in. in depth. The extension rings are provided with knockouts in the sides.

**48. A Waterproof Outlet Fitting Or "Floor Fitting" Or "Floor Body" That Is Used In Floors** (Table 25), and which is sometimes known in the trade as a *floor outlet box* or a *floor box,* is shown in Fig. 17. This "box" is made in two types; one known as the *adjustable floor fitting* and the other as the *non-adjustable floor fitting.* The adjustable type, as shown in Fig. 17, is provided with a movable cover plate which can be aligned with the floor even though the "box" is not accurately set. In the non-adjustable type the cover plate screws rigidly to the "box." With this type, the "box" must

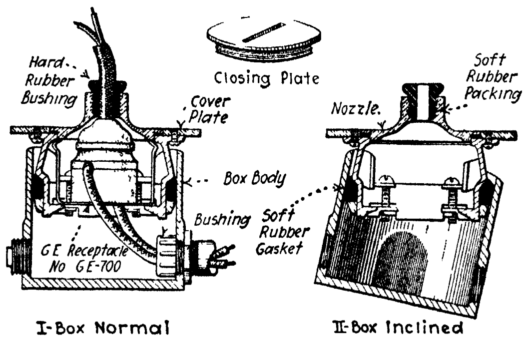



Fig. 17.—Watertight adjustable floor outlet fitting No. 6650 made by the *Sprague Electric Works, New York City.*

be accurately set, if the floor plate is to line up with the floor. The box part is generally made of cast iron or cast brass with an enamel finish. The conduit, in addition to being fastened to the box by the ordinary lockout and bushing, is screwed into a taper-threaded hole in the box, thus making a waterproof joint. The hard-rubber bushing has a soft-rubber compression bushing beneath it which insures a watertight joint between cable and nozzle. The brass nozzle screws into the brass cover plate, thus making a waterproof joint. When the electric device is to be detached from the receptacle, the brass nozzle is unscrewed from the cover plate, the plug withdrawn, and a brass closing plate screwed in the cover plate.

Note.—Other Cast-Iron Waterproof Outlet Fittings are made for marine work. They are plain cast-iron fittings, of round or square shape. These fittings are used for the services indicated in Table 25.

NOTE.—THE CODE REQUIREMENTS AS TO FLOOR "BOXES" are that unless special permission is secured, only *approved* floor outlet "boxes" designed for such service can be used in floors. Ordinarily special permission will be given only when there is every reasonable assurance that the "box" will not be subjected to moisture. An approved floor box must be provided with a waterproof rubber gasket between the box cover and the "box" body. A screw protective bushing, which prevents the entrance of water, must also be provided around the conductors or conduit which leaves the top of the "box."

**49. A Sectional Snap-Switch Box** is shown in Fig. 18. This type of box is made of sheet steel in rectangular shapes of various depths, with removable sides. The box may be

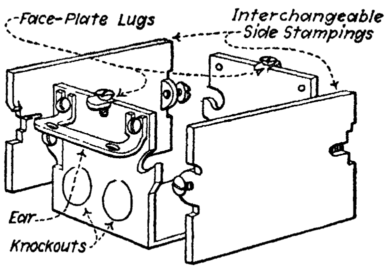



FIG. 18.—Sectional snap-switch box with both sides removable. (*Chicago Fuse Mfg. Co., Chicago, Ill.*)

purchased either with or without the removable sides. The principal feature of this type of box is that several of these boxes may be built up into a gang switch box by removing the sides of the boxes and fastening the units together, leaving a side on each end box. However, one box may be used as a single switch or receptacle box. No covers are required for the sectional snap-switch box as are required for the square conduit box (Fig. 12). In the sectional switch box, the receptacle or switch is fastened directly to the box. In the ordinary conduit installation, the square pressed-steel box with switch cover (Fig. 3) is more often used for a switch outlet box than is the sectional snap-switch box. The box shown in Fig. 18 has both sides removable.

NOTE.—OTHER FORMS OF SECTIONAL SNAP-SWITCH BOXES are made besides the one with two removable sides shown in Fig. 18. Some makes have only one side removable and thus have one partition between each box unit, when the boxes are fastened together to form gang switch

boxes. Other makes require special separators for forming gang switch boxes.

**50. Large Sheet-Steel Boxes,** which usually have a black enamel finish and knockouts, are often used as conduit boxes or cabinets. These boxes are generally used as: (1) *Large junction boxes.* (2) *Large pull boxes* (Fig. 19). (3) *Cabinets.* Different standard sizes and shapes of these boxes are made for the various services which they are to perform. Special steel boxes of almost any shape and size can be had on special order. Fig. 20 shows a convenient *form for ordering* steel boxes.

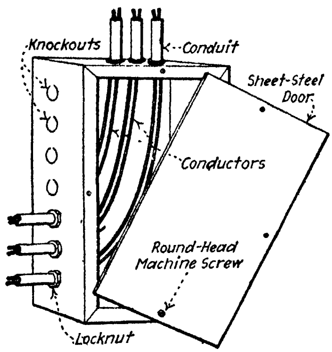



FIG. 19.—Sheet-steel pull box. Same type of box can also be used as junction box.

**51. The Large Sheet-Steel Junction And Pull Boxes,** (Fig. 19), have their four edges turned in and are provided with removable covers fastened with machine screws. They are made in rectangular shape of various dimensions. Specially made boxes with the proper holes cut in them for the conduit are often used as junction and pull boxes in places where the standard box will not serve. The large sheet steel junction boxes are used in places where several conduit runs intersect or cross each other, as for instance over switchboards. The use of large junction boxes in such places, especially over a switchboard, eliminates the complicated conduit arrangement which may otherwise be necessary. Where a large junction box is thus used, since all conductor junctions and crossings are housed in the junction box, the conductors are easier to install and a neater looking switchboard is obtained. Sheet-steel pull boxes may be used where several runs of conduit, lying close together, make a sharp bend (see Fig. 19). When so used they eliminate several costly bends or elbows and also facilitate the pulling in of the conductors.

NOTE.—A SHEET-STEEL BASEBOARD BOX OR DUCT (Fig. 21), called the *Conduo-Base,* is made by the Dahlstrom Metallic Door Co. The

"Conduo-Base," which forms a large metal raceway for conductors along the wall, is well adapted for office buildings. In office buildings many changes in the electrical circuits are continually required after the

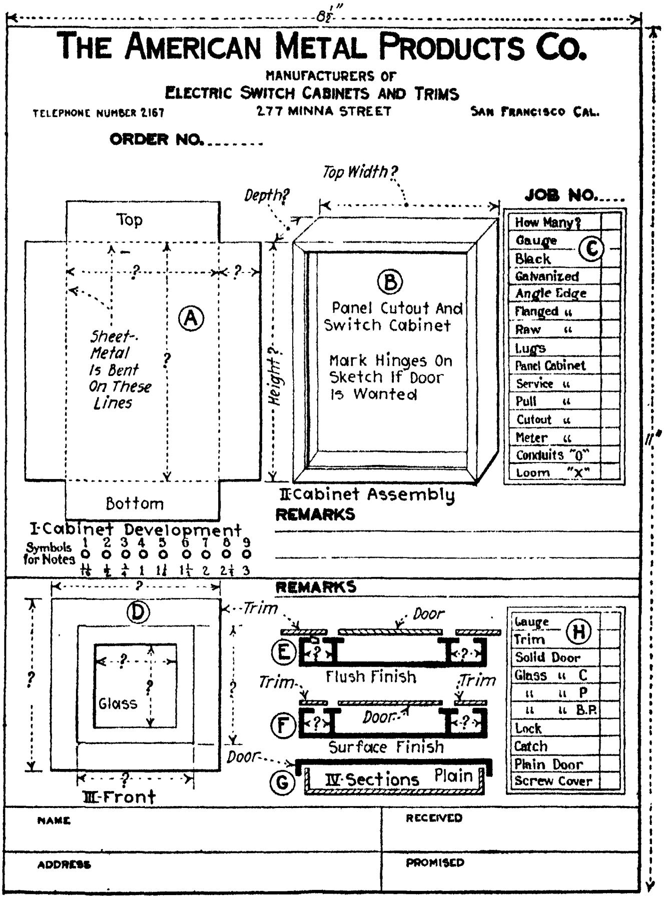



FIG. 20.—Order form which is furnished by one sheet-metal cabinet manufacturer to its customers to insure convenience and accuracy in placing orders. On *A* the sizes and locations of the conduit drillings are shown. On *B* the overall size of the cabinet is specified. In *C* the customer specifies by check marks the box construction details he desires. On *D* the size of the trim, door and glass window (if any) are specified. The trim and door construction which is desired is specified by check marks on *E*, *F*, or *G* and in *H*. Special features are specified under "Remarks."

building is completed. New receptacles must often be installed and switches must be moved. All these changes are difficult to make when the conductors are in concealed conduit, especially when the building is

of concrete. If "Conduo-Base" is installed around the walls of each room, and the conductors are run through it, changes in the circuits can be readily made. All the conductors are accessible and new receptacles can be placed in the base at any point. As shown in Fig. 21 the "Conduo-Base" is divided into two ducts, one for the "high-tension" or 110-volt and the other for "low-tension" or signal conductors.

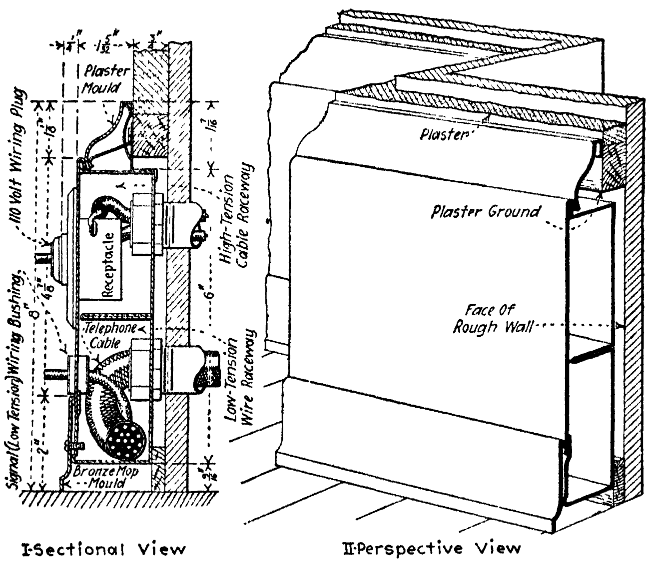



Fig. 21.—Sectional and perspective view of "Conduo-Base." Made by *Dahlstrom Metallic Door Co., Jamestown, New York.*

**52. Cabinets** (sometimes called *panel boxes*) are practically always sheet-steel boxes. They may be of either the *flush type* (*E*, Fig. 20) or the *surface type* (*F* and *G*, Fig. 20). The "flush boxes" are designed for installation in walls or partitions with their outer edges flush with the wall or partition finished surface. The "surface boxes" are designed to be installed with their backs against the wall or partition face and extend wholly from the face.

**53. For Flush Cabinets** rectangular boxes, either similar to or identical with (except as to conduit holes and punchings) the sheet-steel pull boxes, are used (Fig. 22). The only difference between the flush panel box and the pull box is that the *flush panel box* has a steel cover plate or *trim* which laps over the edge of the box and which is provided with a

door, instead of the plain thin sheet-steel cover which is used on the pull box. As a panel box is used to house switches, cutouts, or both switches and cutouts, it is intended to be opened

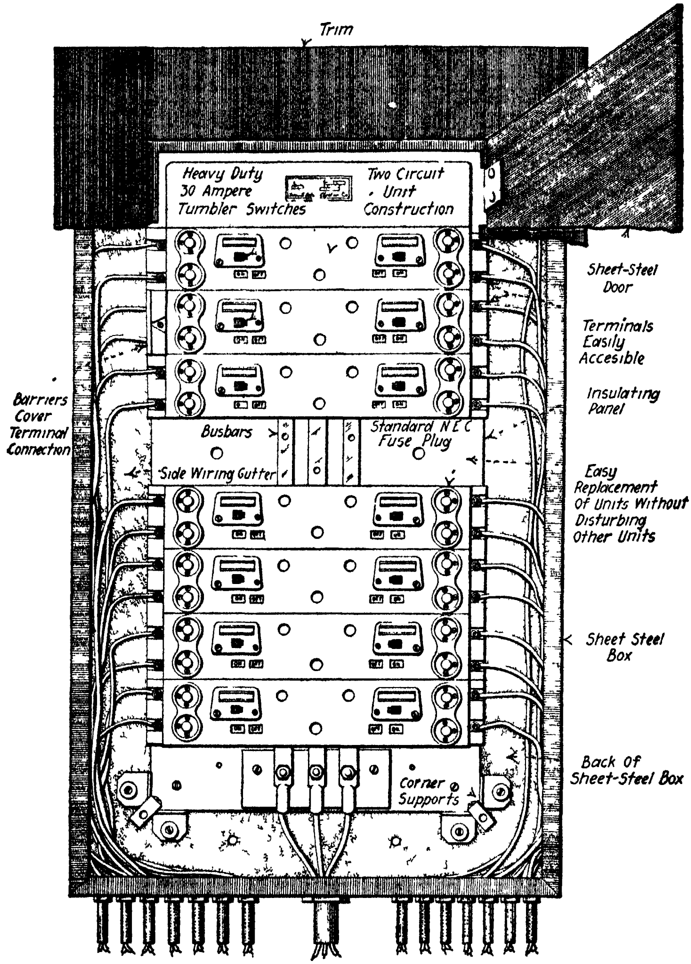



FIG. 22.—Showing panel box with dead-front type panel inserted. (*Frank Adam Electric Co., St. Louis, Mo.*)

frequently. Thus it is provided with a door, has a neater looking cover, which hides the box, and is usually located in a more easily accessible place than the places where pull boxes are located.

**54. Surface-Type Cabinets** (or "panel boxes") often have a sheet-steel door hinged directly to the box (Fig. 4). Since such boxes are intended to project from the wall they are generally used only in exposed-conduit installations. Boxes which have a sheet-steel door hinged directly to the box may, however, be used in concealed-conduit installations, but they do not make as neat an appearance as the flush panel boxes. The principal use of a surface-type box is to house a large knife switch, with or without cutouts, or several cutouts, while the principal use of the flush panel box is to house large panels containing many small switches or cutouts. It is the flush type which is used almost exclusively in office and residential buildings.

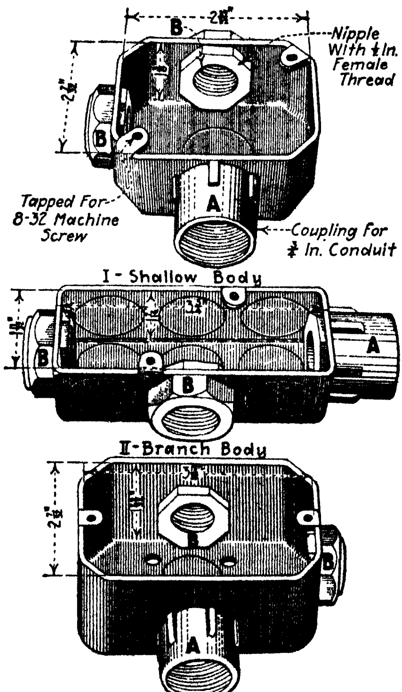



FIG. 23.—Showing outlet fittings of the knockout type. The dimensions of the boxes may vary 1/32-in. from those shown. The sheet steel used for the making of these boxes is 0.080-in. thick. Several different concerns manufacture this line of fittings.

NOTE.—WHEN THE CABINET OR "PANEL BOX" IS COMPLETELY INSTALLED, the whole box unit, including panel, door, etc., is also known as a panel box or cabinet.

NOTE.—THE "BARRIER" OF A PANEL (Fig. 22) is the partition arranged around the edge of the panel and extending from the panel to the front edge of the box. The part within the box, outside of the barrier is called the *wiring gutter* or the *gutter;* see Fig. 22.

**55. Conduit Fittings** (Fig. 5)—see Sec. 30 for definitions—are made in various types and shapes by different manufacturers. They are used chiefly in exposed-conduit installations to serve the functions that conduit boxes (Sec. 28) or conduit

cabinets serve in concealed-conduit installations. They are made of cast iron or of pressed steel by different manufacturers. They can be had in either black-enamel or galvanized finish. Either porcelain or steel covers can be had for most of these outlet fittings.

NOTE.—SMALL CONDUIT BOXES (Fig. 23) are now being made to take the place of a large number of different conduit fittings of the screwed-cover type. They are sometimes called conduit bodies. The advantage of using knockouts is that with only the three conduit boxes shown in Fig. 23 practically all of the combinations required in exposed-conduit installations can be obtained. The boxes are of galvanized pressed steel similar to that used for the standard octagonal conduit box. The boxes of Fig. 23 can be used with either ½ or ¾ in. conduit. For the ¾-in. conduit installations, the nipple and coupling (*A*, Fig. 23) are used. For ½-in. conduit installations the nipple with the female and male threads and the locknut (*B*, Fig. 23) are used. The ½-in. conduit is screwed into the nipple. This line of conduit boxes is made by the SPRAGUE ELECTRIC WORKS, THOMAS & BETTS CO., PRATT-CHUCK CO. and the STEEL CITY ELECTRIC CO.

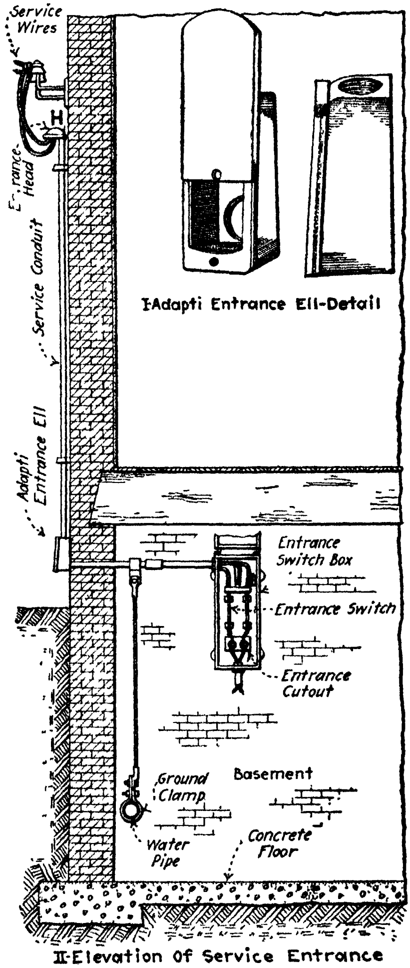



FIG. 24.—Conduit service-entrance arrangement showing service-switch-and-cutout entrance box.

**56. An Entrance Cabinet** *B*, Fig. 24) is a conduit cabinet which is usually placed on the inside of the building, near the point of entrance, for housing the main or service cutouts, or both cutouts and switch if both are in the same case.

is usually placed as near the conduit entrance to the building as possible and always ahead of the meter. The entrance cabinet is generally a sheet-steel box, similar to a panel box or ordinary cabinet. An entrance connection is shown in Fig. 24.

NOTE.—AN ENTRANCE HEAD (*H*, Fig. 24) is a terminal separator (Sec. 38) used at the entrance of the conductors to the conduit system. It is usually a terminal fitting. To be approved by the "National Electrical Code," it must have a porcelain separator cover and must point downward to prevent water from flowing down into the conduit.

**57. The Accessories Generally Required In Conduit Installations,** not including conductors and wiring devices, are: (1) *Couplings.* (2) *Elbows.* (3) *Bushings.* (4) *Nipples.* (5) *Reducers and reducing bushings.* (6) *Locknuts.* (7) *Straps and Hangers.* (8) *Fixture studs.* The accessories here listed are only those required for the installation of the conduit itself. The accessories listed above are required in flexible-conduit installations as well as in rigid-conduit installations with the exception of elbows. Likewise in flexible-conduit installations, box connectors, which serve also as bushings, are used.

**58. The Standard Coupling Used In Rigid-Conduit Installations** is a malleable-iron pipe coupling, covered with either a zinc or an enamel coating. The dimensions of these couplings

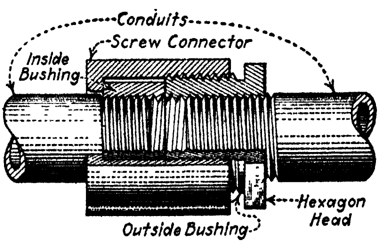



FIG. 25.—The "Erickson" coupling. (*Thomas & Betts Co., New York City.*)

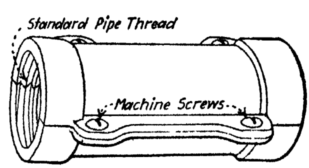



FIG. 26.—Split coupling for rigid conduit. (*Thomas & Betts Co., New York City.*)

are the same as those of standard pipe couplings (see the author's "American Electricians' Handbook," for these dimensions). This coupling, in combination with a running thread and locknut, is also used where a piece of conduit is to be inserted in an existing run (see Sec. 162); it is probably the

least expensive and simplest way of inserting a piece of conduit in an existing run.

NOTE.—SEVERAL SPECIAL COUPLINGS ARE MANUFACTURED which may be used in rigid-conduit installations when it is desired to insert in or remove from an existing run a length of conduit. One of these is the *Erickson* coupling (Fig. 25) which is somewhat similar in construction to the *union* used in pipe installation. Another is the threaded-split coupling shown in Fig. 26. Both of these have the disadvantages, that they are expensive, and are composed of more than one piece. Their advantage is that they make a neater looking job than the running thread. The threaded-split coupling has the further advantage that it may be used in cramped places where a wrench cannot be used.

**59. In Flexible-Conduit Installations, Split Couplings Are Used** for joining the pieces of conduit together. One type

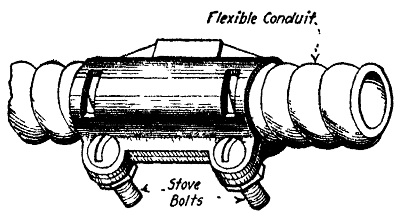



FIG. 27.—Coupling for flexible steel-conduit. (*Thomas & Betts Co., New York City.*)

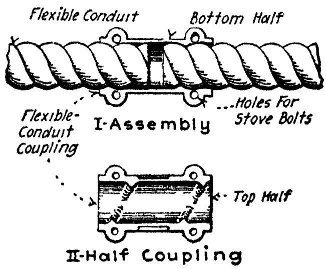



FIG. 28.—Joining flexible-conduit ends with standard coupling.

of split coupling for such use is shown in Fig. 27. Other types of these couplings are made, some with four clamping

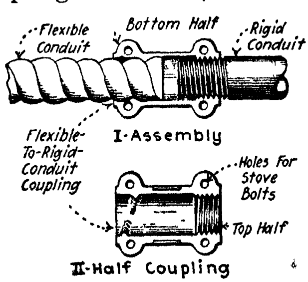



FIG. 29.—Joining flexible conduit to rigid conduit with special coupling.

screws (Fig. 28) instead of two. *Combination couplings* (Fig. 29), which have one end threaded and the other end not threaded, are used to connect flexible conduit to rigid conduit.

**60. The Standard Elbow Used In Rigid-Conduit Installation** consists of a piece of conduit threaded at both ends and so bent that the two ends make a 90-deg. angle with each other. These elbows are made in all conduit sizes. The offsets of the standard elbows vary with the size of the conduit from 7.5 or 6.68 in., depending on the manufacturer, for the ½-in. nominal inside diameter, to 19.37 or 17.25 in. for the 3-in. nominal inside diameter. Special elbows with different degree bends may be had upon order. As a general rule, elbows are seldom used for conduits of diameters less than, say, 1 in., since it is usually more economical and easier to bend the smaller-diameter conduits to the proper curve, at the place of installation, than it is to use standard elbows.

NOTE.—MALLEABLE-IRON PIPE ELBOWS WHICH HAVE A ZINC OR ENAMEL COATING (these are the same elbows as those which steam-fitters and plumbers use) are sometimes employed in conduit installations, near conduit cases. Since it is difficult to pull the conductors through their sharp bends, these elbows should be used only at conduit cases—never in the middle of a run. Their use violates the "National Electric Code" which specifies that the radius of the inner edge of any conduit bend shall be not less than 3½ in. Split pipe elbows (similar to the split pipe coupling shown in Fig. 26) are also sometimes used.

**61. Conduit Bushings** (Figs. 30 and 31), made of malleable iron or of formed sheet steel, are used on the ends of rigid

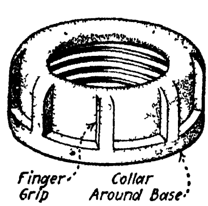



FIG. 30.—Conduit bushing. (*Thomas & Betts, New York City.*)

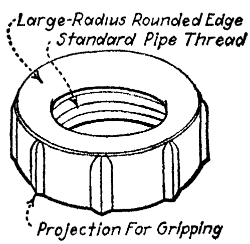



FIG. 31.—Conduit bushing. (*Steel City Electric Co., Pittsburgh, Pa.*)

conduit where the conduit enters a conduit box (Fig. 32) or cabinet. The bushings prevent the conductors, when they are being "pulled in," from rubbing against the sharp edges of the conduit. The bushings may also assist in rigidly connecting the conduit to the conduit box, when no locknut

is placed on the inside of the box. Two types of conduit bushings are shown in Figs. 30 and 31. The type shown in Fig. 30 has a collar around the base and has the advantage that it closes up the hole in the conduit box.

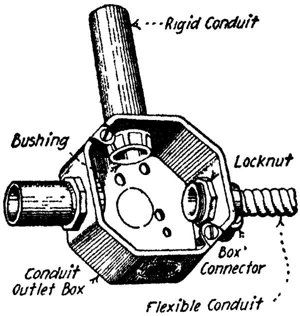



FIG. 32.—Showing rigid and flexible conduit connections to an octagonal conduit box.

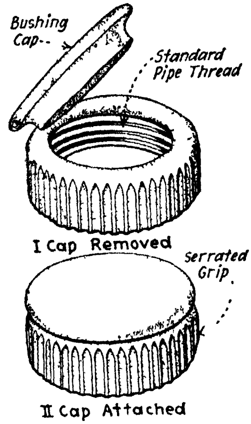



FIG. 33.—Detroit closed bushing. (*Detroit Closed Bushing Co., Detroit, Michigan.*)

NOTE.—CLOSED BUSHINGS, FOR CAPPING THE END OF A CONDUIT RUN, can now be obtained. Conduit systems should be "corked," during the construction of the building to prevent the entrance of moisture, dirt, concrete and the like and to insure a perfectly clean dry raceway into which to pull the conductors. One type of closed bushing is

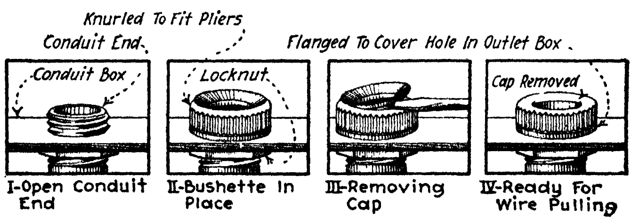



FIG. 34.—Illustrating the application of the *Bushette* which is manufactured by *Walker Bros. & Haviland, Otis Building, Philadelphia, Pa.* The Bushette is made of die-cast zinc.

shown in Figs. 33 and 34. The closed bushing renders unnecessary the use of *wooden plugs* (Fig. 35) or *metal discs* (*sealing discs*) for sealing conduit ends during the construction of the building and prior to the pulling in of the conductors. It also has the advantage over the bushing and disc (Fig. 36), in that the bushing does not have to be removed when the conductors are to be pulled. When closed bushings or standard sheet-metal sealing discs cannot be obtained, copper *pennies* (the one-cent

coin) may be used as discs. Closed bushings or sealing discs are much better than the common wood or paper plugs. The bushings and discs

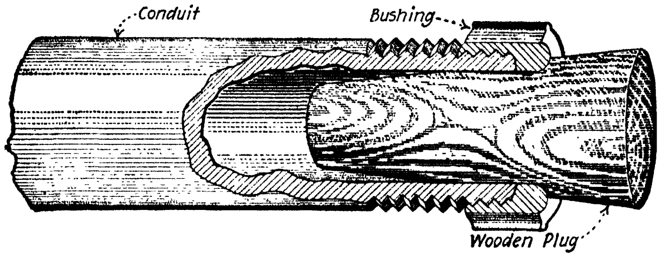



Fig. 35.—Wooden plug for closing conduit end. (*M. B. Austin Company, 700 Jackson Blvd., Chicago, Ill.*) The Austin plugs are so tapered that they can be installed in conduit ends which have or which do not have bushings; they can be used over and over again.

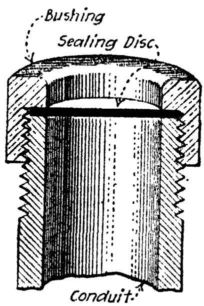



Fig. 36.—Sealing conduit end with a disc.

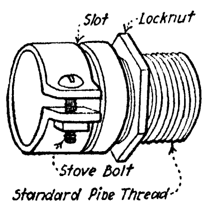



Fig. 37.—"Squeeze" type box connector. (*Sprague Electric Works, New York City.*)

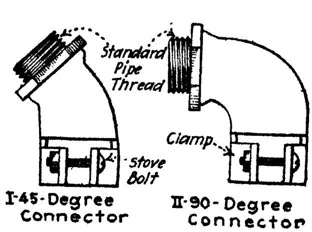



Fig. 38.—Angle, "squeeze" type box connector. (*Sprague Electric Works, New York City.*)

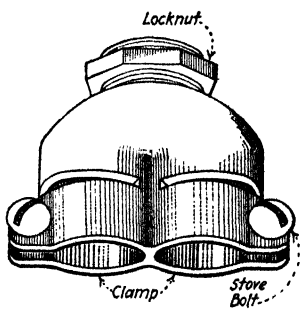



Fig. 39.—Duplex "squeeze" type box connectors. (*The M. B. Austin Co., Chicago, Ill.*)

do not leak, are not easily dislodged accidentally, and they may be readily removed when the conductors are ready to be pulled in.

NOTE.—A FLEXIBLE-CONDUIT BUSHING OR BOX CONNECTOR (Fig. 37) is used where flexible-steel conduit enters a conduit box. These connectors are usually made of cast iron (malleable) but are sometimes formed from sheet steel. One end clamps on the conduit; the other end is threaded so that it can be held in the box by means of a locknut (Fig. 32). These connectors are also made with 45 and 90 deg. angles as shown in Fig. 38, and *duplex* as shown in Fig. 39.

NOTE.—KNOCKOUT PUNCHINGS MAY BE USED FOR SEALING CONDUIT ENDS as in Fig. 36. Use ½-in. *knockout punchings* for ¾-in. conduit and ¾-in. punchings for 1-in. conduit.

**62. Conduit Nipples** (Fig. 40) are sometimes used for the same purpose as are conduit bushings. They have a smooth rounded inside surface and are employed in connection with a conduit coupling to connect the conduit to a conduit box; the end of the coupling bears against the outer face of the box. When this method is used, the box may be removed at any time without disturbing the conduit. The nipple is not frequently utilized as it is more expensive and takes longer to install than the bushing. It may, however, be conveniently used where a conduit is a little too short to reach sufficiently far into a box to take a locknut. For dimensions of the various sizes of conduit nipples see the author's "American Electricians' Handbook."

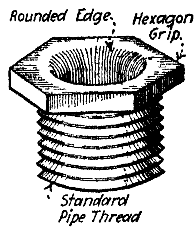



FIG. 40.—Malleable-iron conduit nipple. (*Thomas & Betts, New York City.*)

**63. The Reducers And Reducing Bushings** (sometimes called adapters) used in conduit installation are the same as ordinary steam or water-pipe reducers and reducing bushings. The conduit reducer, however, must have an enamel or galvanized protective finish. Either a reducer or reducing bushing may be employed where a reduction in the size of the conduit is to be made. They are seldom used in concealed work, but are often used in exposed work where it is desired to use larger outlet fittings.

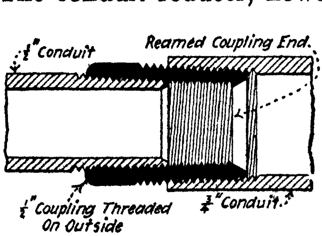



FIG. 41.—Reducing bushing made from an ordinary coupling.

NOTE.—A REDUCING BUSHING MAY BE MADE (Fig. 41) FROM AN ORDINARY COUPLING.—It is possible to make a ¾ to ½-in. bushing from

a ½-in. coupling by cutting a ¾-in. pipe thread on the outside of the coupling. In the same way, a 1 to ¾-in. bushing can be made by threading the outside of a ¾-in. coupling.

**64. Conduit Locknuts** are screwed on the conduit where the conduit enters a conduit box (Fig. 32) or cabinet. These are necessary to connect the conduit to the box rigidly and to insure that the conduit system will be electrically continuous as is required by the "Code." The standard conduit locknuts are thin punched steel nuts, either octagonal or hexagonal in shape (Fig. 42). Another type of locknut, which has been approved by the Underwriters' Laboratories is, as shown in Fig. 43, made of one piece of sheet steel. It has the advantages that it is economical, does not require

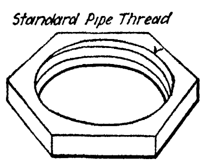



FIG. 42.—Hexagonal punched steel conduit locknut. (*Thomas & Betts, New York City.*)

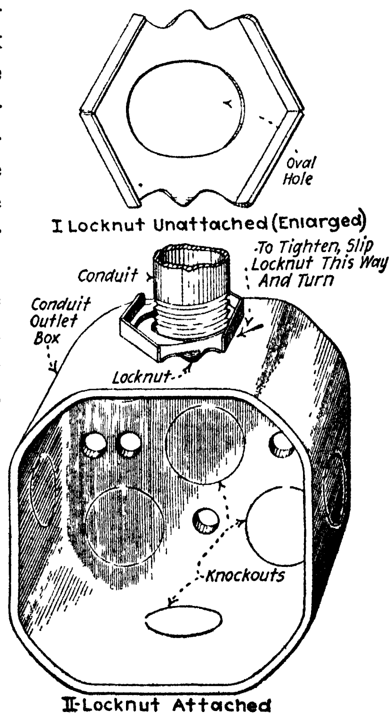



FIG. 43.—The conduit-locknut, called "Condulocknut," made by the *Central Nut Lock Co., 322 S. Michigan Ave., Chicago, Ill.*

good threads on the conduit, and does not have to be screwed on the conduit, since it is simply slipped into position. However, a locknut of this type cannot be readily used on both sides—inside and outside—of a conduit box.

NOTE.—AN IMPROVISED CONDUIT LOCKNUT (Fig. 44) may be made by cutting off (with a hacksaw) from a coupling of the proper pipe size, a piece from ¼ to ⅜ in. long. Such a "locknut" can be set up tight into position with a pipe wrench. Remembering this kink may render unnecessary a trip to the shop to obtain a few missing locknuts.

**65. Conduit Clamps Or Conduit Straps** are simply pipe straps. They are made in various types, sizes, and shapes, each of which has its uses. Some types, as shown in Fig. 45,

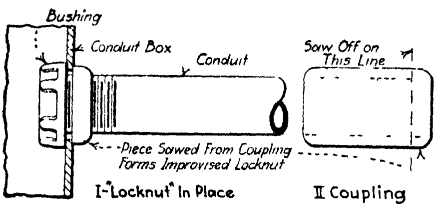



FIG. 44.—"Locknut" improvised from a conduit coupling.

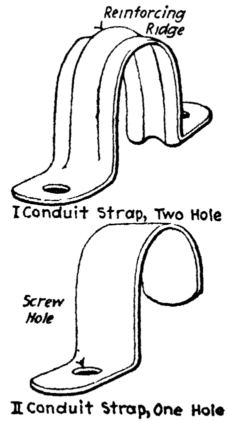



FIG. 45.—Conduit hangers for clamping conduit.

are made for fastening the conduit to wooden members—or to wooden plugs or expansion anchors in holes in masonry members—of the structure. *Conduit hangers* or *conduit*

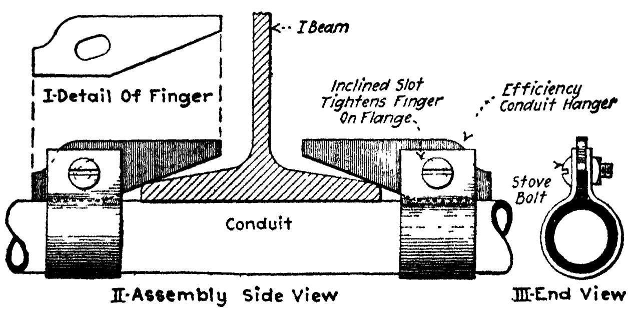



FIG. 46.—"Efficiency" conduit hanger. Made regularly in different sizes for conduits ranging in size from ½ in. to 4 in.; larger sizes are made special. The fingers are adjustable so as to "take" metal flanges ranging from $\frac{1}{16}$ in. to ⅝ in. in thickness. (*Efficiency Electric Company, East Palestine, Ohio.*)

*supports* (Figs. 46, 47 and 48) are made for fastening the conduit to or suspending it from I-beams and other structural members. *Toggle bolts* are used for fastening conduit clamps

to tile or to metal-lath surfaces. A few common types of toggle bolts are shown in the author's "American Electricians' Handbook."

NOTE.—CONDUIT STRAPS are made with either one or two holes to accommodate the supporting screws or nails (Fig. 45). The straps with the two holes will, obviously, hold the conduit more firmly or will hold a

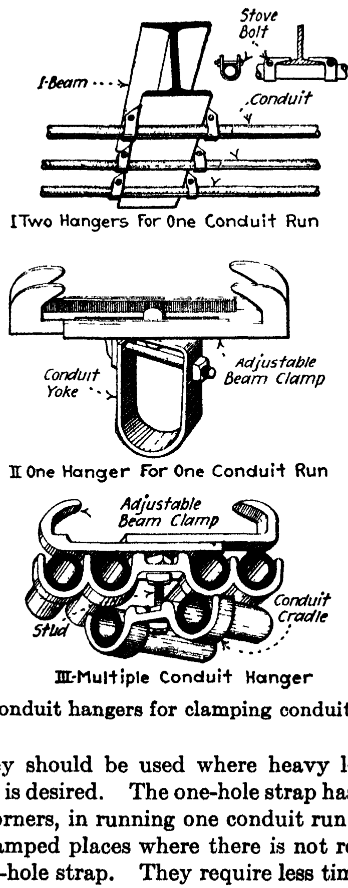



FIG. 47.—Conduit hangers for clamping conduit to I-beams.

greater load. They should be used where heavy loads are carried or where rigid support is desired. The one-hole strap has the advantage that it can be used in corners, in running one conduit run close to an existing run, or in other cramped places where there is not room enough for the two legs of the two-hole strap. They require less time to install because they are fastened by only one screw or nail. However, the two-hole strap may also be fastened in only one place, if desired, by leaving the other hole open.

NOTE.—OUTLET BOX HANGERS (FIG. 49) should be used where a heavy vertical load, such as that due to a large luminaire, will be imposed on an outlet box. See Sec. 174 for further information.

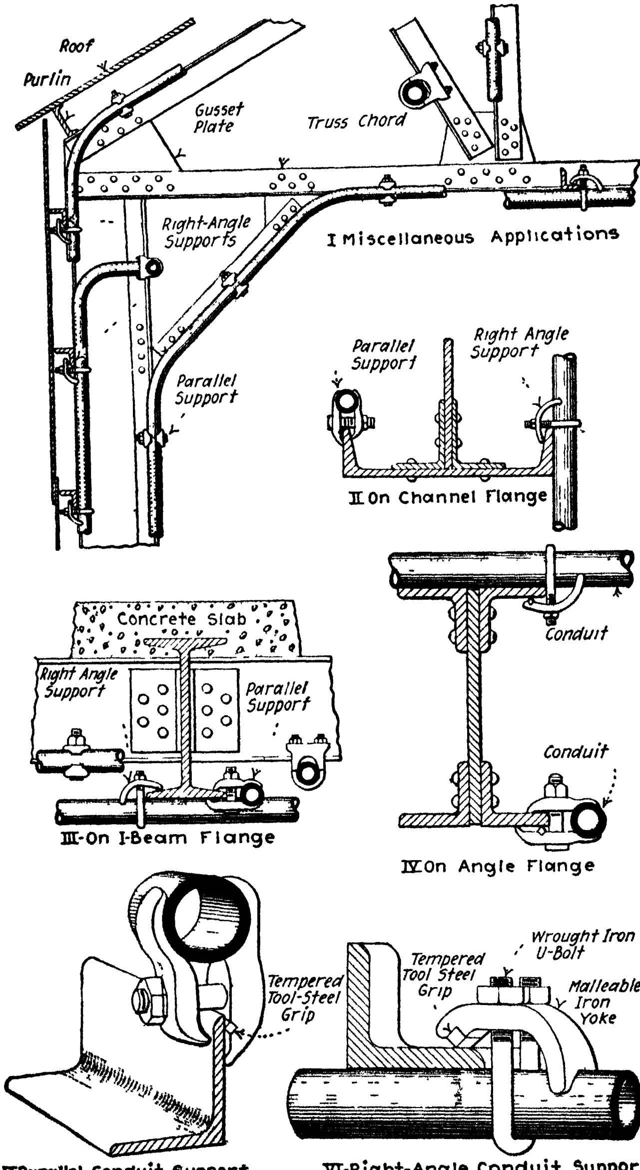



FIG. 48.—Conduit supports, for structural steel members, made by the *C. G. Korns Co., Johnstown, Pa.*

**66. A Fixture Stud** (Fig. 50) is a stud which is attached to an energy outlet box or fitting for the purpose of supporting a fixture. A fixture stud may be used for the support of

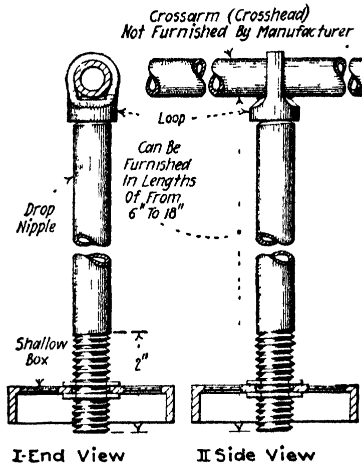



FIG. 49.—Outlet box hanger, for use where heavy loads are to be supported. (Patented by *The Thomas & Betts Company.*)

either ceiling or wall-bracket fixtures. The crow-foot type, which is generally used, is held to the conduit box by

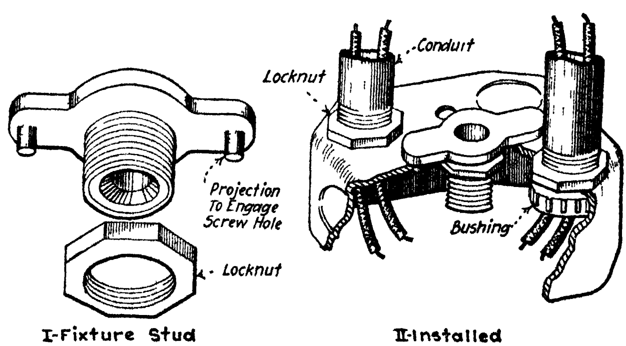



FIG. 50.—New Kwikon "No-Bolt" fixture stud. (*S. R. Fralick & Co., Chicago, Ill.*)

three or four small stove bolts (Fig. 9). A relatively new type is shown in Fig. 50. This is easier to attach than the crow-foot type as with it only one nut—a locknut—has to be

tightened. Other types are made and sometimes used under special circumstances.

**67. Knockout Fillers Or Caps** are used for closing up (*blanking*) knockout holes. They can be purchased for

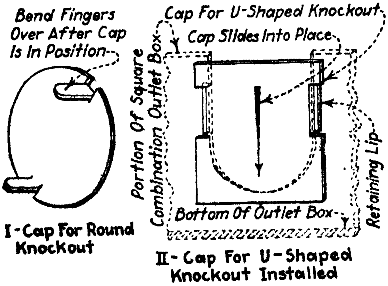



Fig. 51.—Knockout caps made by the *Trumbull Electric Mfg. Co., Plainville, Conn.*

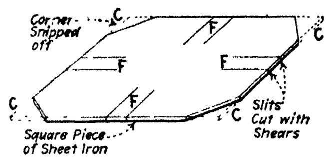



Fig. 52.—Showing how filler is cut.

closing either round or U-shaped holes, as shown in Fig. 51. An improvised knockout filler can be made of sheet iron as indicated in Figs. 52 and 53. The piece of sheet iron is cut

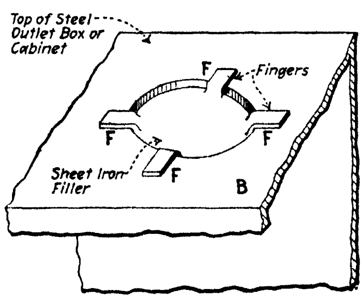



Fig. 53.—Appearance of sheet-steel filler in position.

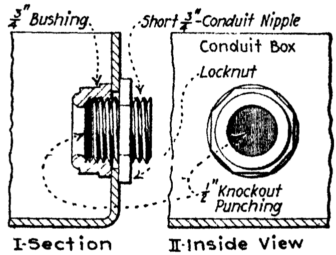



Fig. 54.—"Blanking" a knockout hole with a knockout punching, a bushing, a nipple and a locknut. No inspector can decline to pass this, whereas those methods which employ thin sheet iron are sometimes not accepted. For 1-in. conduit use a ¾ in. punching.

along the lines indicated in Fig. 52. The corners, *C*, are cut off. The fingers, *F*, are then bent vertically upward, pushed

through the knockout hole, and again bent down to the position shown in Fig. 53. Other improvised methods of blanking knockout holes are shown in Figs. 54, 55 and 56.

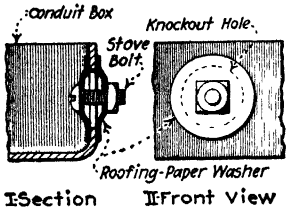



FIG. 55.—"Blanking" a knockout hole with roofing washers. Paint all, after completion, with black stove-pipe enamel.

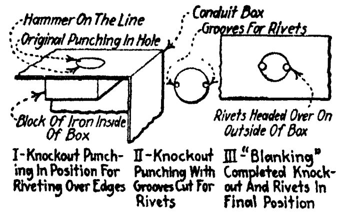



FIG. 56.—In *I* and *III* is shown the method of "blanking" a knockout hole with a knockout punching and two rivets. (Often the punching may be securely fastened, without using rivets, merely by pounding around the edge of the punching, on the outside of the box, against an iron block held inside of it as at *I*.)

**68. Wire For Installation In Conduit,** must to conform to "Code" requirements, be rubber-covered except in permanently dry, hot locations where slow-burning insulation may be permitted. Single-braid wire is permitted for single conductors smaller than No. 6. For single conductors larger than No. 6, or for duplex or multiple conductors, double-braid wire should be used. Each conductor must be continuous from outlet to outlet without splices or taps. Solid wires may be used for conductors up to No. 8, but for conductors of No. 6 and larger stranded wires should be employed.

NOTE.—IN DAMP OR OTHERWISE "HAZARDOUS" LOCATIONS, lead-covered or specially treated wire should be used as explained in Div. 12. Conductors in conduit, which operate at pressures exceeding 600 volts, between generators or motors and switchboards should generally be multi-conductor leaded cables.

**69. An Elexit** is a patented electric-outlet device which renders lighting fixtures portable (Fig. 57). An Elexit receptacle, which is concealed by an inconspicuous brass cover plate, can be installed in either a wall (Fig. 58) or ceiling outlet case (Fig. 59). Any lighting fixture which is equipped with a suitable Elexit plug can be attached to it quickly and

without the aid of tools. Any portable appliance may also be plugged into an Elexit receptacle—if it is not being used for lighting purposes. Both the standard tandem- and the

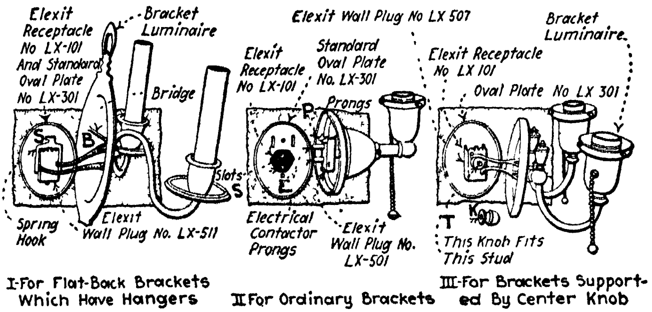



Fig. 57.—Standard wall Elexit receptacles and plugs and wall fixtures of different designs, showing how the fixtures attach to the Elexits.

*I*—To hang bracket, insert plug and slide bracket bridge, *B*, over spring hook, *S*, of Elexit plug, which provides a snug fit for various bridges.

*II*—To hang bracket, insert prongs, *P*, in the topmost slots, and slide bracket downward into locked position, the electrical contactor prongs *E*, engaging in slots, *S*. Canopy is then slipped back against the wall to cover the plug and receptacle plate. To disengage, loosen set-screw and slip canopy forward, pull releasing spring and raise slightly.

*III*—To hang luminaire, insert plug, slip bracket over threaded stud, *T*, and screw up center knob, *K*.

parallel-blade universal plugs will fit the wall Elexit receptacle. The purpose of an Elexit is to allow for unlimited changing

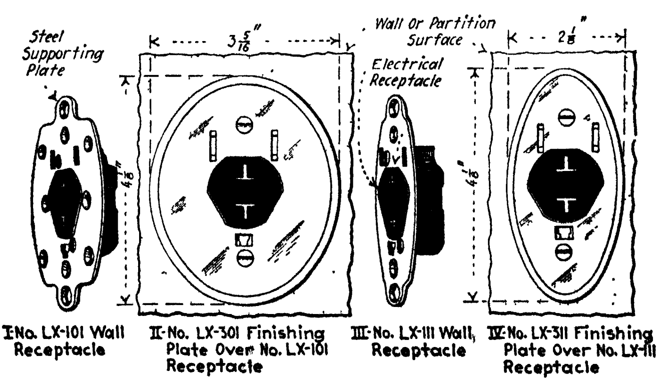



Fig. 58.—Standard wall Elexit receptacles, and receptacles in position under finishing plates.

of luminaires (lighting fixtures) so that they will harmonize with any architectural or color scheme of furniture and decoration.

**70. Luminaires Can Be Changed Almost Instantly Wherever An Elexit Is Located.**—The Elexit plugs have metal supporting casings which contain the electric connection plugs. This casing is provided with hook projections which lock into the Elexit receptacle and carry the weight of the fixture. To remove the casing from the receptacle, it is only necessary

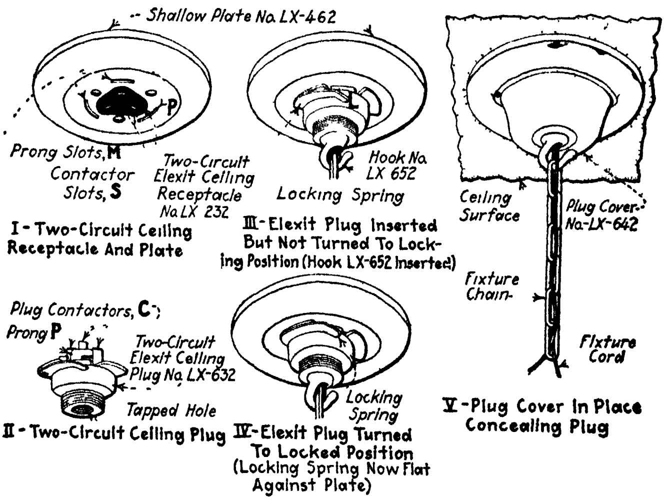



FIG. 59.—Elexit ceiling receptacles and plug. This shows two circuit receptacles and plugs. Single-circuit receptacles and plugs are made and are like the above except that they have only 2 plug contactors $C$, and only two contactor slots $S$. These Elexits may be installed in any $3\frac{1}{4}$ in. or 4 in. outlet box which has a stud. The plug will support fixtures weighing up to 100 lb. *To Attach A Ceiling Fixture To An Elexit*, insert the prongs, $P$, in the slots, $M$, and turn to the right until the spring, $L$, clicks. To detach, lower $L$ and turn the plug to the left.

to release a small spring catch. This is easily done but it must be done intentionally. The positive lock prevents any chance of the fixture being accidentally dislodged and falling and breaking. The Elexit has been approved by the Underwriters' Laboratories. Elexits can be installed with any system of concealed wiring.

**71. The Elexit Receptacles And Plugs Are Of Two General Types:** (1) *Wall type*, Fig. 57. (2) *Ceiling type*, Fig. 59. Both are discussed below. Any Elexit wall plug will fit any Elexit wall receptacle. Any Elexit ceiling plug will fit any Elexit ceiling receptacle. But the wall plugs will not fit

the ceiling receptacles nor will the ceiling plugs fit the wall receptacles.

NOTE.—THE ELEXIT HAS BEEN STANDARDIZED for interchangeable use. An Elexit plug will fit the corresponding Elexit receptacle, regardless of what manufacturer made either part. A number of different manufacturers are now making Elexits.

**72. How To Install Wall-Type Elexit Receptacles** is explained in the following which is taken from Bryant Electric Co., publications and from an article by E. C. White in *Electrical Merchandising.* The use of outlet plates for either wall or ceiling outlets is discouraged. Outlet boxes which will provide the conditions herein outlined should be installed,

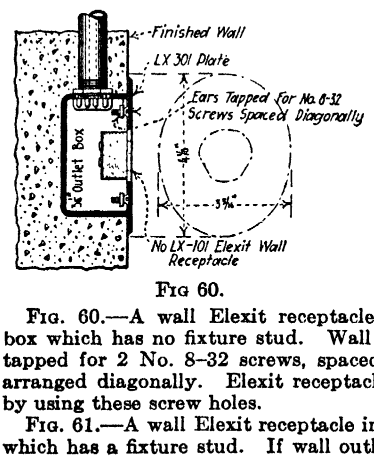



FIG 60.

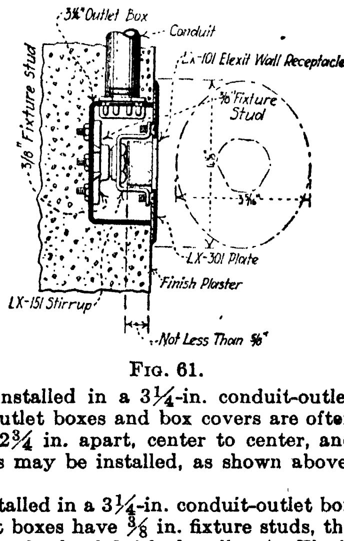



FIG. 61.

FIG. 60.—A wall Elexit receptacle installed in a $3\frac{1}{4}$-in. conduit-outlet box which has no fixture stud. Wall outlet boxes and box covers are often tapped for 2 No. 8–32 screws, spaced $2\frac{3}{4}$ in. apart, center to center, and arranged diagonally. Elexit receptacles may be installed, as shown above, by using these screw holes.

FIG. 61.—A wall Elexit receptacle installed in a $3\frac{1}{4}$-in. conduit-outlet box which has a fixture stud. If wall outlet boxes have $\frac{3}{8}$ in. fixture studs, the end of each stud must be at least $\frac{5}{8}$ in. back of finished wall. An Elexit receptacle can then be installed at any time.

even for knob-and-tube installations. The wiring contractor should bear in mind that, in the majority of cases, he will sell the *Elexit receptacle and plate* and must install them so as to receive the *Elixilier* (any lighting fixture arranged to be mounted on an Elexit receptacle) in an acceptable manner. Under all circumstances extreme care must be used to set the receptacles exactly flush with the wall face, otherwise the plugs will not seat with the wall surface. Detail instructions are:

Oval Wall Receptacles.—Elexit wall receptacles must always be installed flush. LX-101 receptacle (Fig. 58-*1*) consists of a steel supporting plate with an electrical receptacle attached. These two parts do not come separately. The steel supporting plate has screw holes so located as to permit Elexit installation under various standard outlet-box conditions. The electrical receptacle has double-T slots and will accommodate the parallel-blade cap of standard attachment plugs, as well as any Elexit plug for wall brackets. Connect the outlet wires to the binding screws of the receptacle. The steel supporting plate which takes the whole strain of supporting any wall bracket fitted with an Elexit plug, is then securely attached to the outlet by any of the following means:

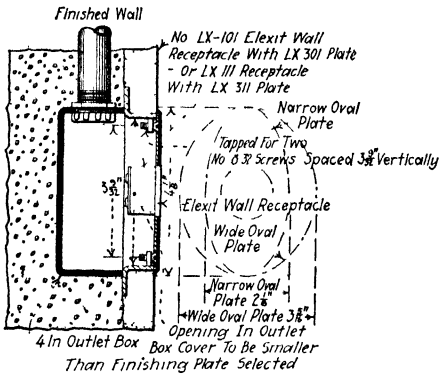



Fig. 62.—An Elexit wall receptacle installed in a 4-in. conduit outlet box which has no fixture stud. If wall outlet box covers are tapped for 2 No. 8–32 screws spaced 3 9/32 in. apart, and arranged vertically, Elexit receptacles may be installed by using these screw holes. If the openings in such box covers are sufficiently narrow, the Elexit receptacles may be finished with narrow oval plates as illustrated above.

On 3¼-In. Outlet Boxes Without Fixture Stud (Fig. 60).—Standard boxes of this size are either round or octagon, are 1½ in. deep and have two tapped lugs spaced 2¾ in. on centers diagonally. Attach LX-101 receptacle directly to the lugs with No. 8-32 screws furnished with receptacle.

On 3¼-In. Outlet Box With Stud (Fig. 61).—If end of the ⅜ in. fixture stud is ⅝ in. or more back of wall, screw LX-151 wall stirrup on to the stud so that tapped holes in stirrup are horizontal. Then attach the steel supporting plate to stirrup with No. 8-32 screws furnished with receptacle.

On 4-In. Outlet Boxes With Box Covers (Fig. 62).—If box cover has tapped lugs which are spaced 3 9/32 in. on centers vertically, or spaced 2¾ in. on centers diagonally, attach the steel supporting plate directly to lugs with screws furnished with receptacle. If box cover has no lugs, attach to fixture stud using LX-151 stirrup as described above. If

end of fixture stud is 1¼ in. or more back of wall, use LX-153 stirrup which is like LX-151 but longer.

ON BOX COVERS 52C63 AND 54C63 (Figs. 63 and 64).—These box covers are sold by ten outlet-box manufacturers for 4-in. square and 4-in.

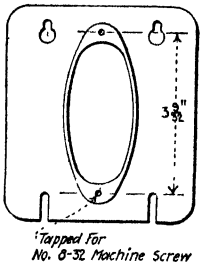



FIG. 63.— No. 52–C–63 square, 4-in. box cover for Elexit narrow oval plate.

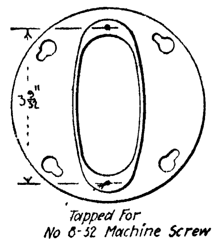



FIG. 64.—No. 54–C–63 round 4-in. box cover for Elexit narrow oval plate.

round or octagon boxes respectively, and are tapped on 3⁹⁄₃₂-in. centers vertically so that steel supporting plate may be attached directly to cover by screws furnished with receptacle. Either LX-101 (Fig. 58-*I*) or LX-111 (Fig. 58-*III*) receptacles can be attached to these covers.

OVAL FINISHING PLATE.—After an LX-101 receptacle has been installed by any of the above methods, attach LX-301 finishing plate (Fig. 58-*II*) to the steel supporting plate with screws furnished with the finishing plate. Outside dimensions of this plate are 4⅛ in. high × 3⁹⁄₃₂ in. wide × ⅛ in. deep.

NARROW OVAL WALL RECEPTACLE.—LX-111 wall receptacle (Fig. 58-*III*) is the same as LX-101 except that the steel supporting plate is narrower. This eliminates most of the holes provided for attachment. The LX-111 can only be attached to outlet boxes by screws spaced 3⁹⁄₃₂ in. on centers vertically. They should, therefore, be installed as follows:

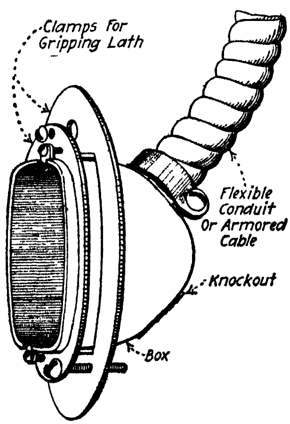



FIG. 65.—No. 11 Rim-clamp outlet box for wall Elexit outlets in completed buildings.

NARROW OVAL WALL RECEPTACLE ON 4-IN. OUTLET BOXES WITH BOX COVERS.—Square boxes with No. 52C63 box covers (Fig. 63), or round or octagon boxes with 54C63 box covers (Fig. 64) should be used. The steel supporting plate of LX-111 is then attached directly to the box cover with two No. 8-32 screws which are furnished with the receptacle.

NARROW OVAL FINISHING PLATE.—After LX-111 receptacle has been installed by any of the above methods, attach LX-311 finishing plate

(Fig. 58) to the steel supporting plate with screws furnished with the finishing plate. Outside dimensions of this plate are: 4⅛ in. high., 2$\frac{1}{16}$ in. wide, ⅛ in. deep.

ADDITIONAL OUTLETS IN COMPLETED BUILDINGS.—No. 11 rim-clamp box (Fig. 65) is intended to provide a metal-lined opening for fishing wires or steel-armored cable and also a finished support for either LX-101 or LX-111 (Fig. 58-*I* and -*III*) wall receptacles. The clamps are made to grip the lath on both sides, and the box is then installed flush and the clamps are plastered in. The front clamp has two tapped holes spaced 3$\frac{9}{32}$ in. vertically on centers, to which the steel supporting plates of the Elexit receptacles are attached direct with two No. 8-32 screws, which are furnished with the receptacle.

PLUGS FOR RIGID ATTACHMENT TO WALL BRACKETS.—LX-501 plug (Fig. 57-*II*) is threaded with a ⅜-in. standard female thread for permanent attachment to slip-canopy brackets, or it may be brushed down for use on brackets which are supported by center knobs. Plug LX-507 (Fig. 57-*III*) is the same as LX-501 except that it is threaded with a ⅛-in. standard male thread. It is used for supporting brackets supported by center knobs, as in Fig. 57-*III*. Or it may be permanently attached to slip-canopy brackets made of ⅜-in. brass tubing.

IN ATTACHING THESE PLUGS TO SLIP CANOPY BRACKETS (as in Fig. 57-*III*, for example) care should be taken to see that the back edge of the canopy will slip to a position ⅛ in. back of the back edge of the plug, since this is the relative position the canopy will occupy when the bracket is installed on an Elexit receptacle.

PLUG WITH SPRING HOOK FOR BRIDGE BRACKETS.—Plug LX-511 (Fig. 57-*I*) is for attaching brackets which are provided with an *attachment bridge B*, Fig. 57-*I*. Only the fixture cord extends between the plug and the bracket. Sufficient slack cord should be allowed so that the plug may be conveniently inserted in the receptacle and then the attachment bridge, *B*, is slipped over the spring hook, *S*. Care should be taken to see that the bridge is permanently so set into the back of the bracket that the front of the bridge is not more than ⅜ in., and the back of the bridge is not less than $\frac{3}{16}$ in., within the bracket edge which rests against the wall.

**73. How To Install Ceiling-Type Elexit Receptacles** will be evident from a study of Figs. 59, 66, and 67. To permit the installation of ceiling Elexits, every ceiling-outlet box should have a ⅜-in. fixture stud and the end of the stud should be at least ⅝ in. above the finished ceiling level. Then the Elexit ceiling receptacle can be installed at any time.

**74. How To Connect Elexiliers** (lighting fixtures arranged for installation on Elexit outlets) is shown graphically in Figs. 68, 69, 70, 71, 72, 73, and 74. Elexit wall and ceiling

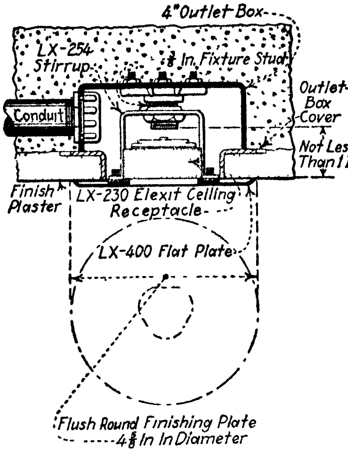



FIG. 66.

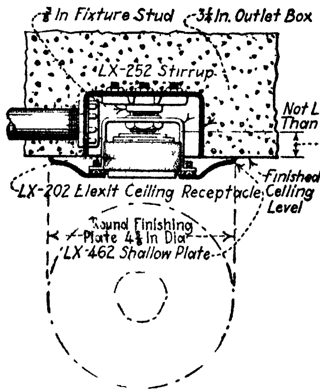



FIG. 67.

FIG. 66.—Flush ceiling Elexit receptacle installed in a 4-in. conduit-outlet box. If the ⅜-in. fixture stud is at least 1 in. above the finished ceiling level, Elexit receptacles may be installed flush with the ceiling surface as shown.

FIG. 67.—Extending (non-flush) ceiling Elexit receptacle, installed in a 3¼-in. conduit outlet box. If the ⅜-in. fixture stud is more than ⅝ in. but less than 1 in. above the ceiling level, the receptacle may be installed as shown.

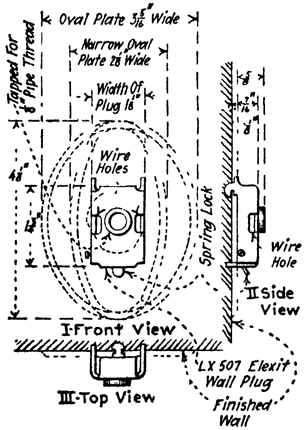



FIG. 68.

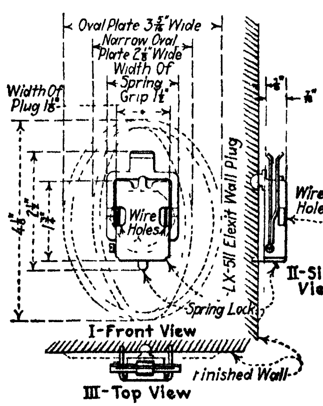



FIG. 69.

FIG. 68.—Dimensions of No. LX-507 wall plug installed on Elexit wall receptacle. No. LX-507 is tapped ⅛ in. for center knob brackets only. It can be wired only through holes in the side of the plug. *To Take Down Bracket*, unscrew center knob and release spring lock.

FIG. 69.—Dimensions of No. LX-511 wall plug installed on Elexit wall receptacle. No. LX-511 has a spring hook over which the back-bar, strap, saddle or bridge of the wall bracket is hooked. Simply connect fixture wires to binding screws of plug. *To Take Down Bracket*, lift it off hook and release spring lock.

plugs have large binding screws to which the fixture wires are connected. The electric connecting plug is contained in the

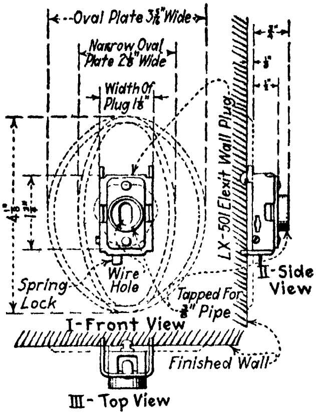



FIG. 70.—Dimensions of No. LX-501 wall plug installed on Elexit wall receptacle. No. LX-501 is tapped with a ⅜ in. pipe thread for rigid attachment to bracket arms or center knobs. Can be wired through tapped opening or through side holes. *To Take Down Bracket*, slip canopy forward or unscrew center knob and release spring lock.

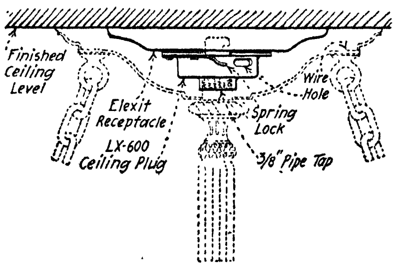



FIG. 71.

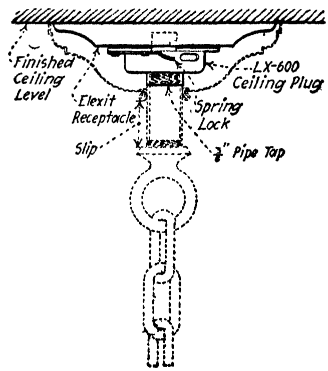



FIG. 72.

FIG. 71.—Method of using No. LX-600 plug on ceiling bands, showers and other ceiling fixtures where the central support is not used for carrying wires. The plug is wired through the side openings and attached to the fixture by the bottom or lock nut. *To Take Down This Type Of Fixture*, unscrew the bottom knob and release spring lock.

FIG. 72.—No. LX-600 ceiling plug for use on ceiling fixtures with slip canopies. In such cases simply attach No. 5LX-600 plug in place of a hickey and connect the fixture wires to the binding screws within the plug. *To Take Down This Type Of Fixture*, slip down canopy and release spring lock.

casing which supports the fixture but does not carry any of the weight of the fixture. The supporting casing is strongly

made and locks into position in the receptacle. To remove the casing from the receptacle it is necessary to release a small spring latch. The dimensions given in the illustrations are of interest particularly to those who assemble and mount fixtures.

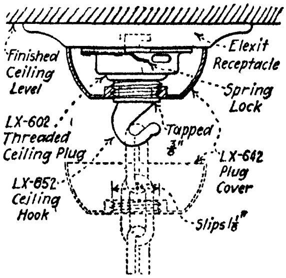



FIG. 73.

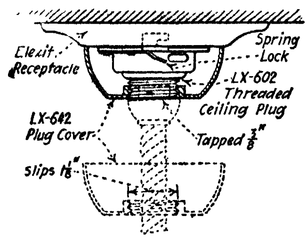



FIG. 74.

FIG. 73.—No. LX–602 ceiling plug with No. LX–642 plug cover used with No. LX–652 hook to support standard lighting unit with chain hanger. *To Take Down Lighting Unit*, unscrew plug cover and release spring lock.

FIG. 74.—No. LX–602 ceiling plug with No. LX–642 plug cover used to support standard lighting unit with plain or ornamental cord hanger. *To Take Down Lighting Unit* unscrew plug cover and release spring lock.

**75. The Underwriters' Laboratories Inspects And Labels Many Types Of Electrical Appliances And Materials.**—This organization is maintained by the National Board of Fire Underwriters. These inspections are made at frequent intervals and serve as continuous checks upon the standard of manufacture maintained at factories which furnish labeled products. The labels are placed only on such completed products as conform in all essentials to established standards. The labels do not necessarily signify uniformity in quality or merit but only compliance with the Underwriters' Laboratories standards. Semi-annually, a list of the approved electrical appliances is published; in this list, the names of the manuacturers of approved appliances together with the location of their headquarters and the catalogue numbers of their approved appliances are given in alphabetical order under each appliance heading.

**QUESTIONS ON DIVISION 2**

1. What is the conduit method of wiring? What is the conduit? Of what materials are conduits made? What are the advantages and disadvantages of a conduit system?

2. Name and describe the two types of metallic conduit used in interior wiring.

3. Describe the three forms of flexible conduit and state the advantages and disadvantages of each form.

4. What are the relative merits of rigid and flexible conduit?

5. What is armored cable?

6. Describe the manufacture of rigid conduit.

7. Name the five classes of rigid conduit.

8. Name and describe the three methods of coating a conduit with zinc. What are the relative merits of the conduits coated by each of the methods? How can electro-galvanized conduit be distinguished from the other zinced conduits?

9. What are the advantages and disadvantages of enameled rigid conduit compared with zinced rigid conduit?

10. How are conduit sizes specified? How do the sizes of rigid and flexible conduit compare? What is the smallest-sized conduit generally used?

11. Define the term *conduit case*. What are the functions of a conduit case?

12. Make a table of the classification of conduit cases.

13. Define the term *conduit box*. What other terms is it given in the trade?

14. Define the term *conduit fitting*.

15. Define the term *conduit cabinet*. Name its functions.

16. Name and define the various classes of conduit boxes. Conduit fittings.

17. What are round, square, and octagonal boxes? What functions may they perform? What is a conduit (outlet) plate?

18. State the recommendations of the chart devised by the New York Division of Lighting Fixture Manufacturers in regard to the types of outlets boxes to be used. In regard to the hanging of heavy ceiling fixtures.

19. Describe and illustrate the universal numbering system. State its advantages.

20. Describe the "Universal Key" for matching wiring devices, steel boxes, and covers. State its advantages.

21. Give the advantages and use of the two-piece pressed-steel box. Of the extension rings.

22. Describe the floor outlet "box" and state its uses.

23. Describe the sectional snap-switch box and state its uses.

24. What type of box is used as a large junction or pull box? State the uses of large junction and pull boxes.

25. Describe the construction of cabinets, both flush type and surface type. What are the respective uses of the flush type and surface type? Define the term *barrier* when used in connection with a panel.

26. What are the different types of conduit fittings made?

27. What is an *entrance box*? What is an *entrance head*?

28. Name the accessories generally used in conduit installations. Are any other materials needed for completing the installations?

29. Describe the standard couplings used in rigid and flexible-conduit installations. Describe and show the use of an Erickson coupling. How may rigid conduit be connected to flexible conduit?

30. What type of elbows are used in rigid-conduit installations? Are they always used and why?

31. What are conduit bushings? Closed conduit bushings? What is used instead of a bushing in flexible-conduit work?

32. What is a conduit nipple and where is it used?

33. What are conduit reducers and reducing bushings and what is their use?

34. What are conduit locknuts used for?

35. Draw sketches of and explain a few types of conduit hangers and conduit supports.

36. What are fixture studs used for? Explain.

37. Draw a sketch of several types of knockout fillers or caps and give their uses.

38. What is an Elexit? What are their advantages? Describe the construction of both the wall and ceiling types of Elexits.

39. Describe the method of installing a wall-type Elexit receptacle in various types of outlet boxes. Describe the construction of the various types of Elexit plugs.

40. Describe the method of installing a ceiling-type Elexit receptacle in various types of outlet boxes.

41. Explain how to connect Elexiliers to Elexit outlets.

42. What is the Underwriters' Laboratories and what functions does it perform?

## DIVISION 3

## LAYING OUT A CONDUIT JOB

**76. The Wiring Plans And Specifications** (for conduit jobs in buildings), which are furnished to the wireman, ordinarily vary in completeness for buildings of different types. For some small buildings, the plans show only the locations of the varous switch, fixture, and receptacle outlets and of the wall switches (Fig. 94). The specifications for these small buildings are also, generally, quite closely written. Often they require only that the wiring shall fulfill the requirements of a certain local wiring ordinance or of the "National Electrical Code." The complete specifications for a large theatre conduit-wiring job will be found in the author's "Lighting Circuits And Switches."

**77. The Wiring Plans For Very Large Buildings** (Figs. 75, 76, 77 and 78)—which are always wired in conduit—generally show the locations of all outlet boxes, pull boxes, panel boxes, motors, and the like, together with the approximate conduit locations and the number and size of wires in each. Frequently, the wattage to be consumed at each energy outlet is indicated by a number (showing the watts to be taken therefrom) near the outlet, as in Figs. 96 and 97. Such plans often also plainly indicate the branch circuit to which each outlet is to be connected and the switch control which is to be provided for various circuits. The specifications for such large buildings are also usually so written as to describe fully the materials, method of construction, and workmanship which are required. In any event, the plans and specifications, for any building whatsoever, should be studied very carefully before any work is started.

NOTE.—THE MEANINGS OF WIRING SYMBOLS, as adopted by various organizations, are given in the author's "American Electricians' Handbook." Furthermore, an explanation of the symbols used in any set of plans should be, and often is, given on the plans themselves. This is to

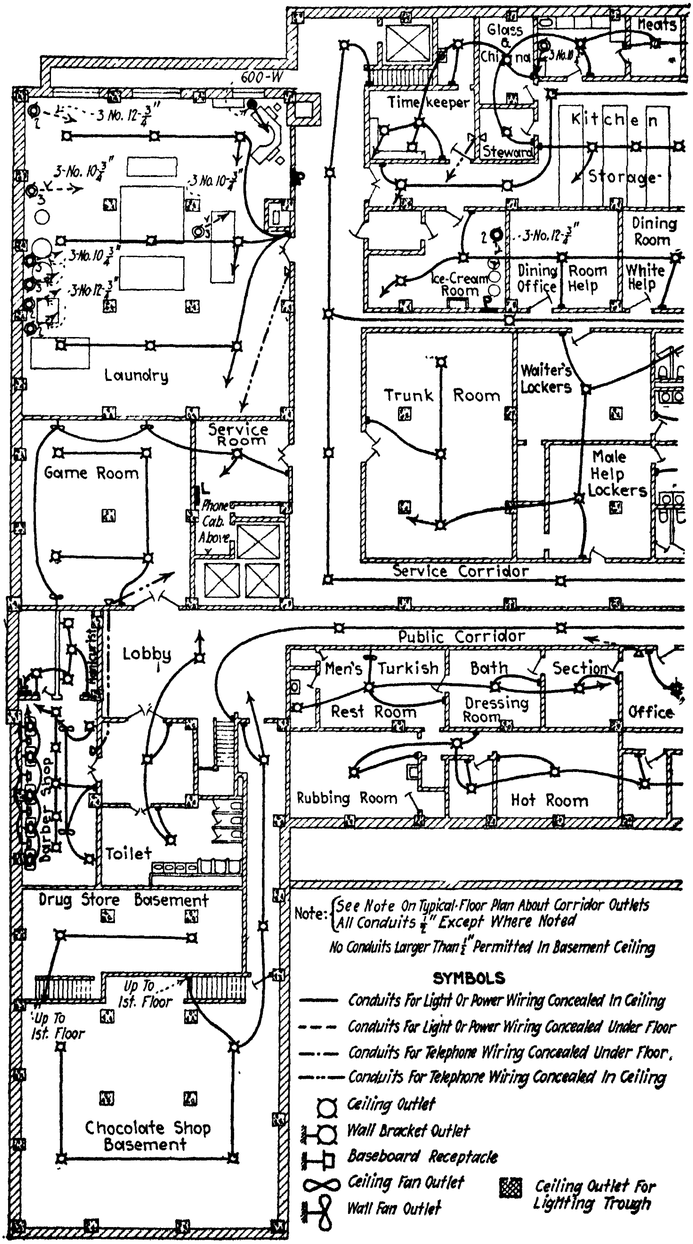
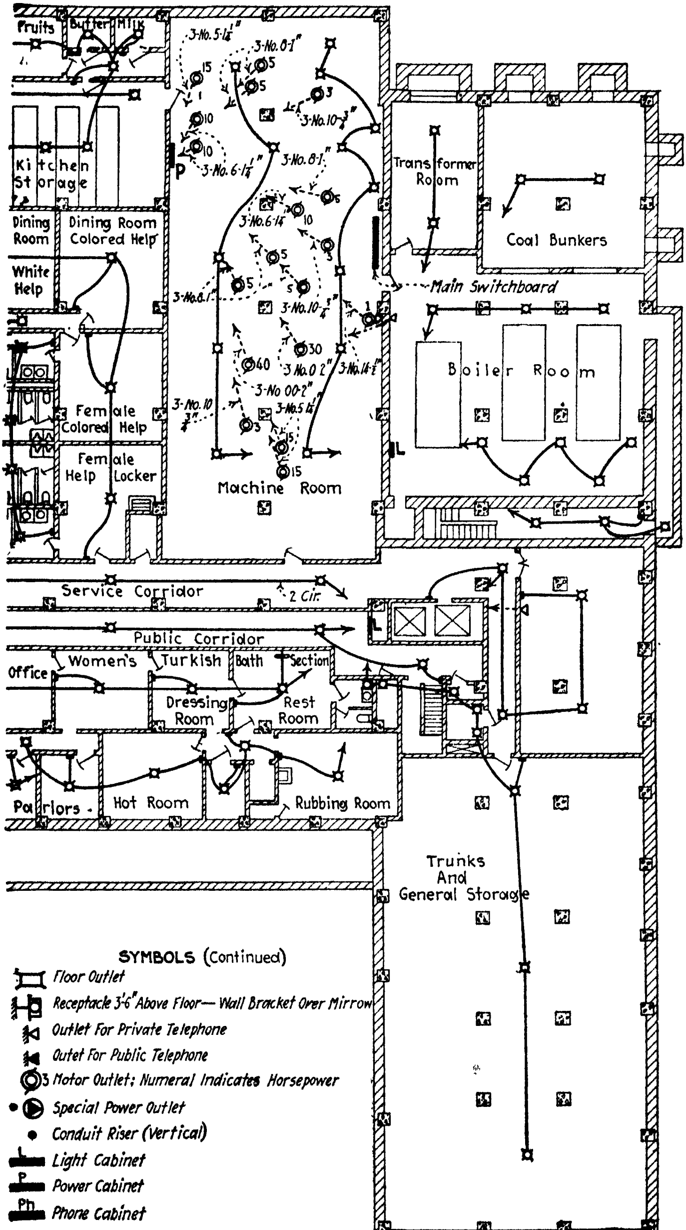



**Fig. 75.—Conduit-wiring diagram for basement of a hotel.**
***Electric Co.*, electrical**




(*Chase Hotel, St. Louis; P. J. Bradshaw,* **architect,** ***Rick-Chapline*** **contractors.)**

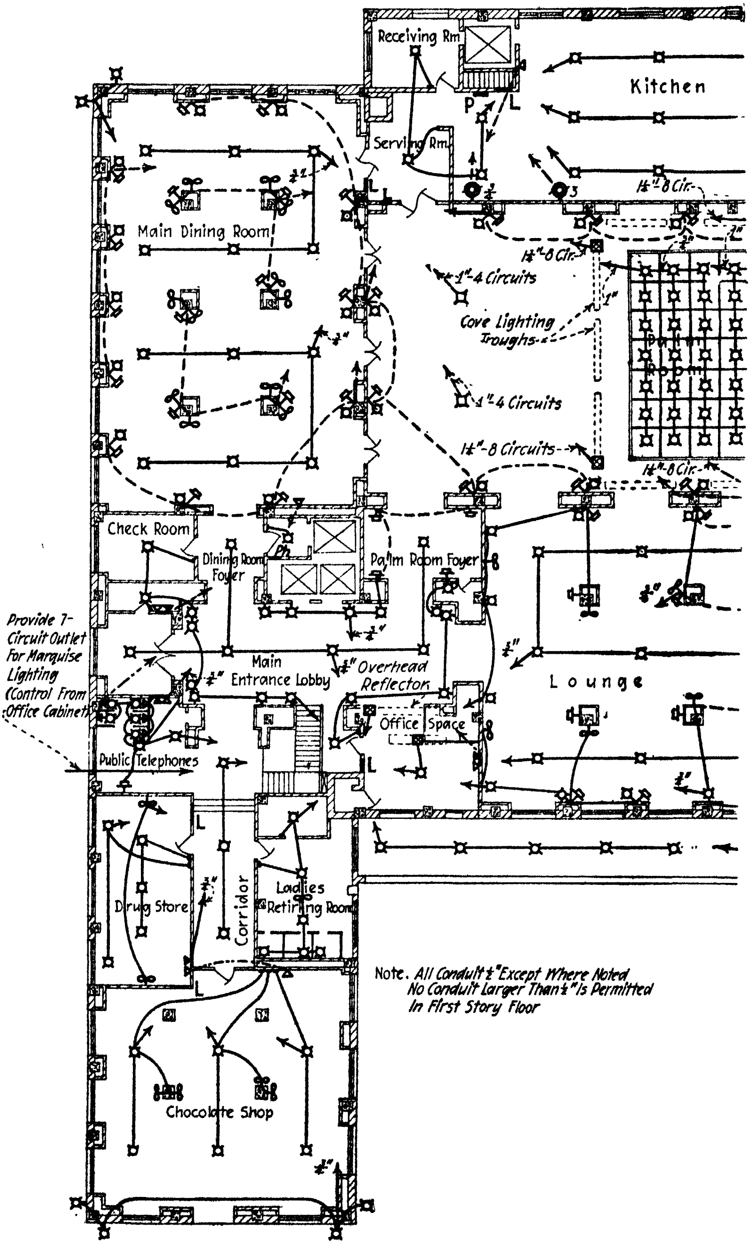



**Fig. 76.—Conduit-wiring diagram for main floor of a hotel, for symbols see** *Electric Co.*, **electrical**

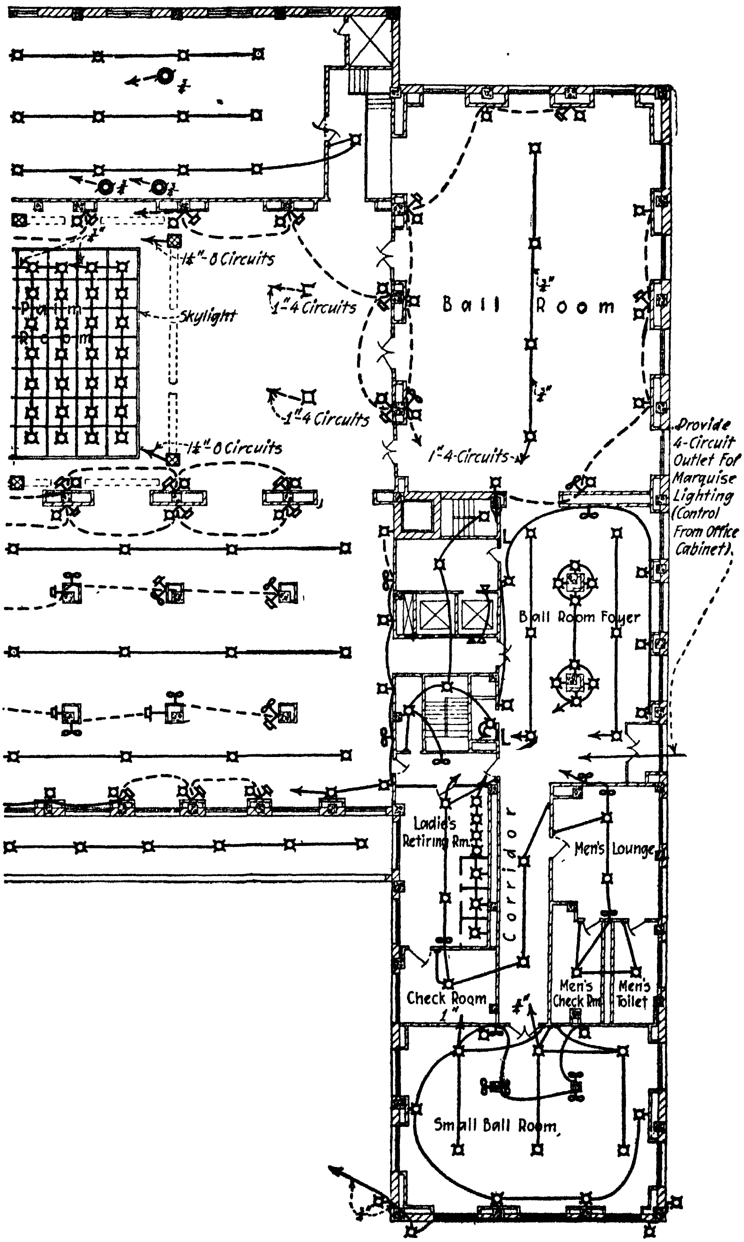



**Fig. 75.** (*Chase Hotel, St. Louis; P. J. Bradshaw*, architect, *Rick-Chapline* contractors.)

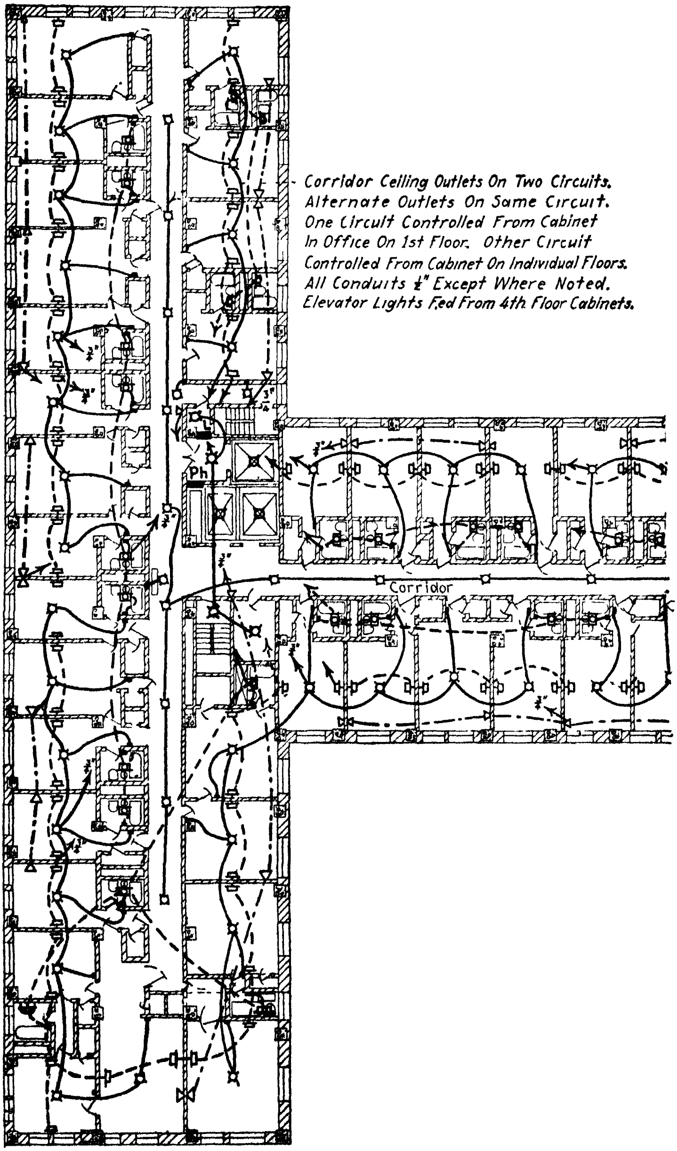
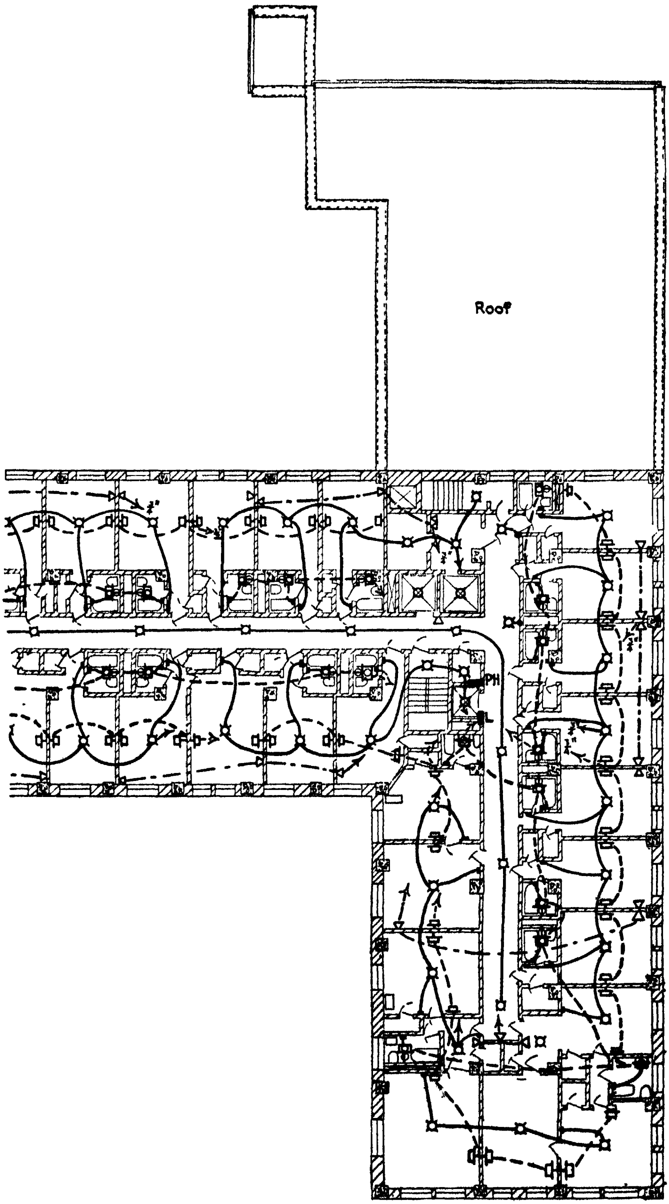



**Fig. 77.—Conduit-wiring diagram for typical floor of a hotel, for symbols**
***Electric Co.*, electrical**




see Fig. 75. (*Chase Hotel, St. Louis; P. J. Bradshaw*, architect, *Rick-Chapline* contractors.)

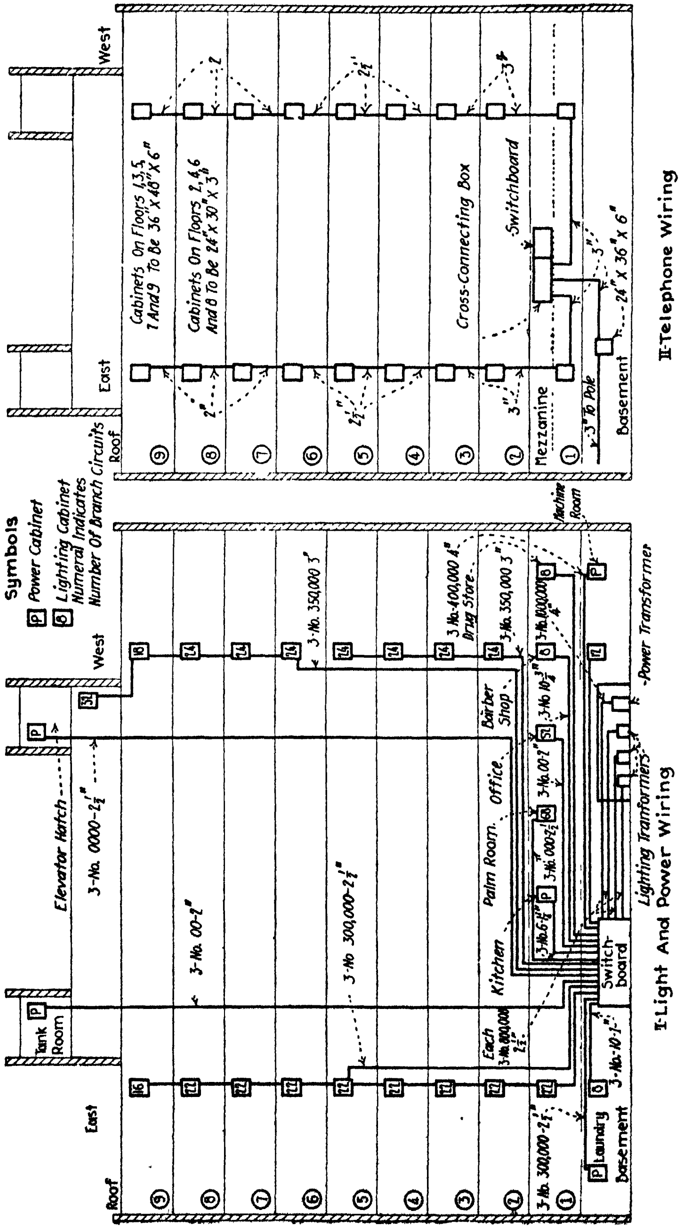



FIG. 78.—Riser diagrams of conduit wiring in a hotel building. (*Chase Hotel, St. Louis; P. J. Bradshaw, architect, Rick-Chapeline Electric Co., electrical contractors.*)

avoid misunderstandings. Should any symbol which is used on a plan be not understood, the meaning of the symbol should be ascertained by consulting the engineer or architect who drew the plans.

**78. Wiring Plans For A Large-Residence Conduit-Wiring Job** are shown in Figs. 79, 80 and 81. These are executed

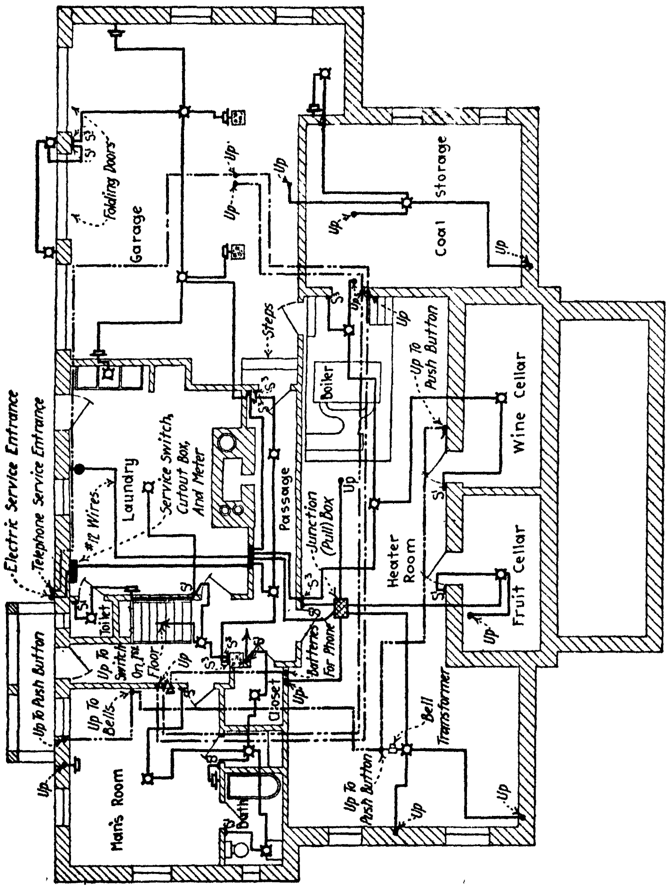



FIG. 79.—Basement plan of a large residence showing conduit runs. See Fig. 80 for symbols. (*Frank Adam Electric Co., contractors.*)

rather more carefully than is the practice of the average architect for residence work. But for any building as large as this one, experience has shown that wiring plans prepared carefully before the work is started will more than justify their cost. If the architect or engineer does not furnish

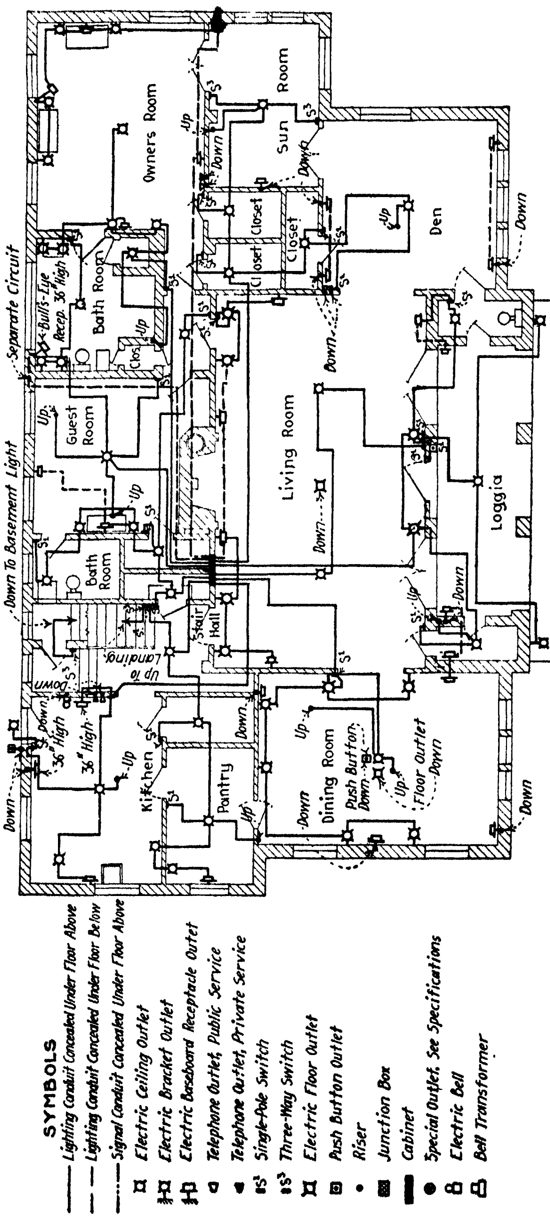



FIG. 80.—First-floor plan of a large residence showing conduit runs. (Same residence as in Figs. 79 and 81.)

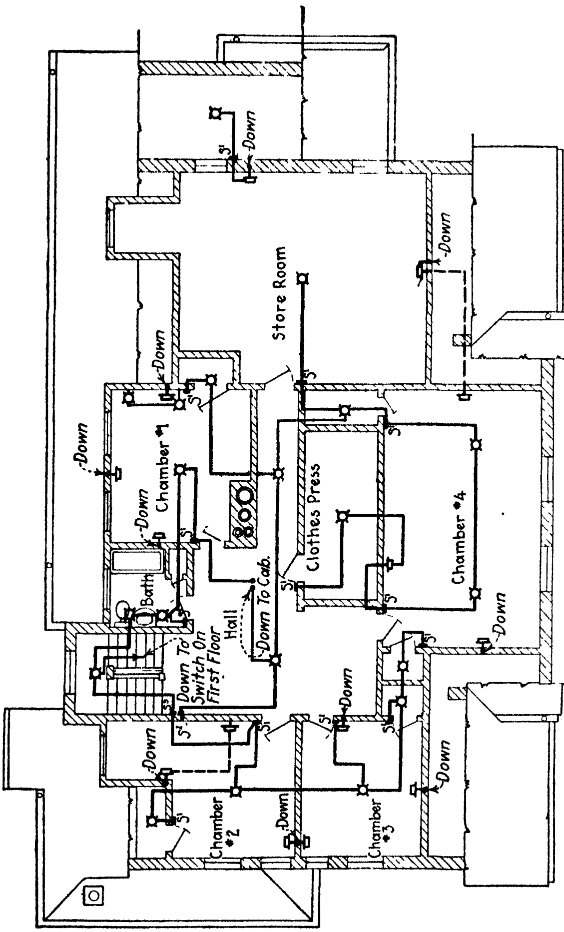



FIG. 81.—Second-floor plan of the residence shown in Figs. 79 and 80 showing conduit runs in 2nd story. See Fig. 80 for symbols.

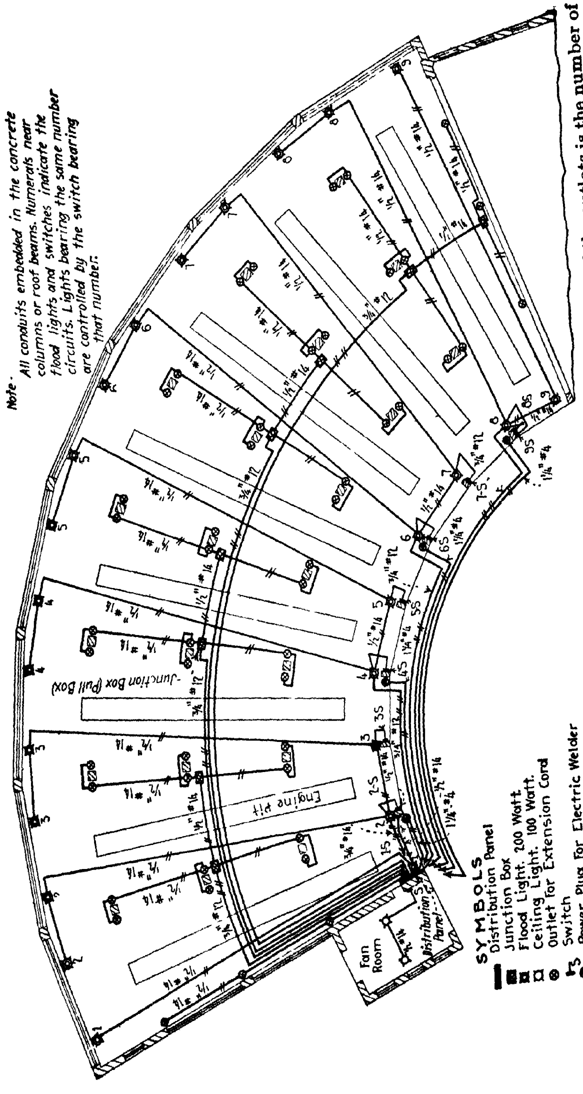



**FIG. 82.—Plan showing conduit wiring for a round house.** The number near most of the outlets is the number of the branch circuit to which the outlet is connected. (Electric work done by *Rick-Chapline Electric Co., St. Louis.*)

carefully prepared working plans for such jobs, it will pay the wiring contractor to do so at his own expense.

NOTE.—THE WIRING PLAN FOR AN INDUSTRIAL BUILDING (Figs. 82 and 83) may differ from those for other buildings in that it may show many industrial electrical devices such as motors and electric heating and welding equipment. Wherever a motor or other electrical device

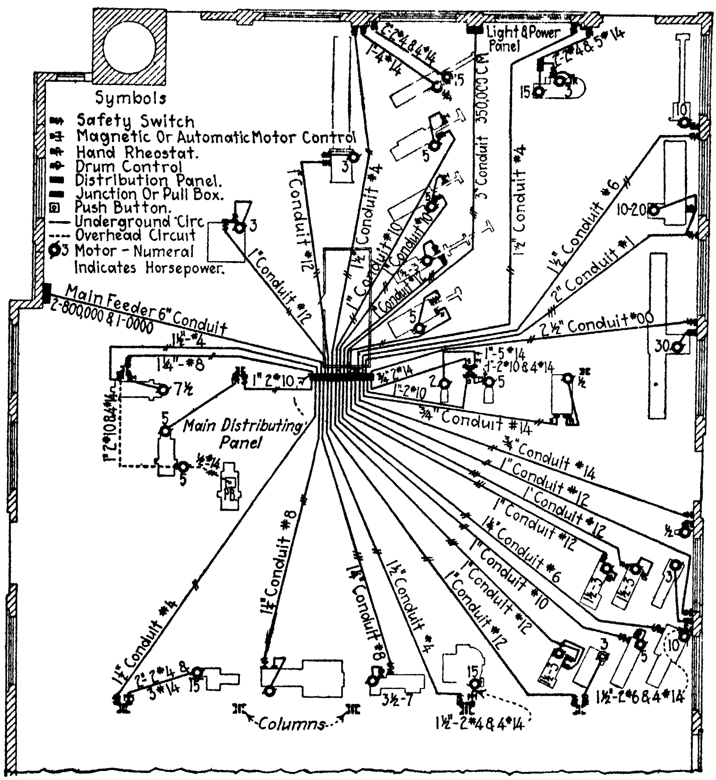



FIG. 83.—Plan showing the power wiring for a portion of a machine shop.

which takes over 660 watts is shown on a plan, its rating in horsepower or watts—preferably in watts—should always be indicated on the plan, in numerals, adjacent to the symbol which locates the device.

**79. The Inductive Effects Of Alternating Currents** should be well understood by conduit wiremen. Wherever a single conductor carrying alternating current passes near or through a metallic—electrically conducting—body (such as a tube or a

plate, Fig. 84), the alternating current in the conductor sets up eddy currents in the body. The effect is much more pronounced when the conductor passes through the body. The eddy currents represent an energy loss. They may dangerously heat the body in which they circulate, and they create a drop in voltage in the conductor.

Note.—When the metallic body is non-magnetic (such as aluminum, brass, or copper), the voltage drop, eddy-current energy loss and the possible heating due to the presence of the metallic body, near or around

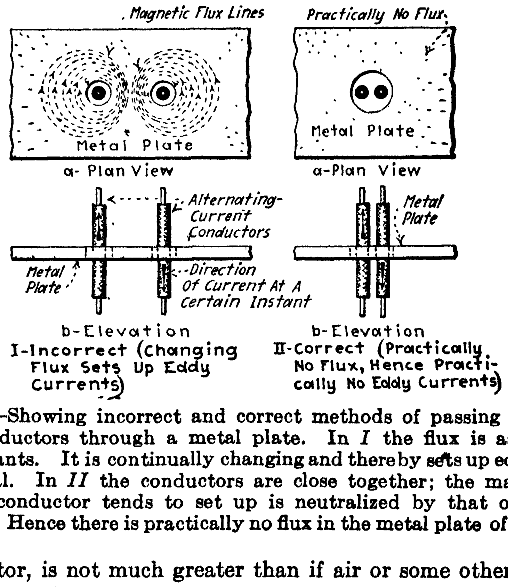



Fig. 84.—Showing incorrect and correct methods of passing alternating-current conductors through a metal plate. In *I* the flux is as shown, at certain instants. It is continually changing and thereby sets up eddy currents in the metal. In *II* the conductors are close together; the magnetic field which one conductor tends to set up is neutralized by that of the other conductor. Hence there is practically no flux in the metal plate of *II*.

the conductor, is not much greater than if air or some other insulating substance were in the space which is occupied by the metallic body. But all of these will be increased somewhat by the presence of the metallic body. However, if the metallic body is magnetic (iron or steel, or, in much less degree, nickel) the voltage drop, eddy-current loss and consequent heating occasioned by the presence of the body will be much greater than if the space were occupied by a non-magnetic substance. This is because an alternating current of a given value in a conductor will set up a very much greater magnetic flux—which will produce a correspondingly greater induced current—in an adjacent magnetic substance than in a corresponding non-magnetic substance.

**80. To Minimize These Eddy Currents And The Accompanying Losses,** all of the wires of an alternating-current circuit must be passed through the same hole (Fig. 84–II)

in any metallic object and should always be kept as close together as possible. Thus in a three-wire or a three-phase system, all three wires must be carried in the same conduit and through the same holes of metal plates. Similarly, in a two-phase system all of the wires of a circuit must be carried through the same hole or conduit. Figs. 85 and 86 show correct arrangements. Even plates of 1/16-in. thickness have given trouble where single conductors carrying heavy alternating currents were passed through them.

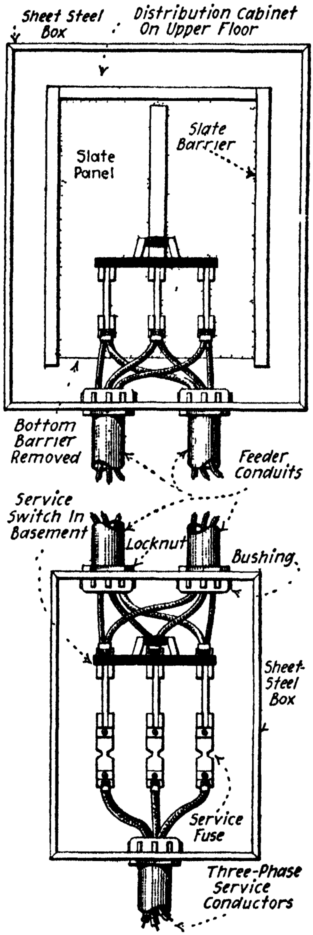



FIG. 85.—Split-conductor three-phase feeder in conduit. The diagram shows the proper conductor arrangement to minimize inductive effects.

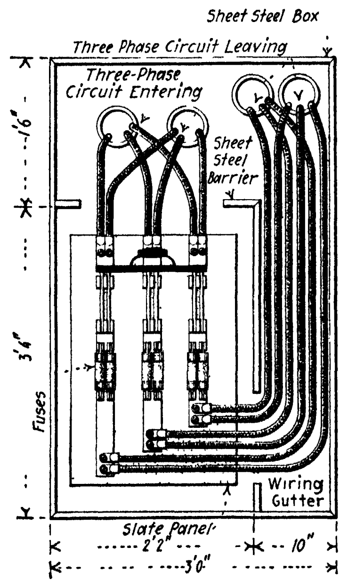



FIG. 86.—Split conductor arrangment in a sheet-steel box containing a 1,200-amp., 250-volt, switch, which opens a three-phase circuit.

EXAMPLE.—Connections made as shown in Fig. 87 gave trouble due to eddy currents. The heating was so bad that the insulation on the wires

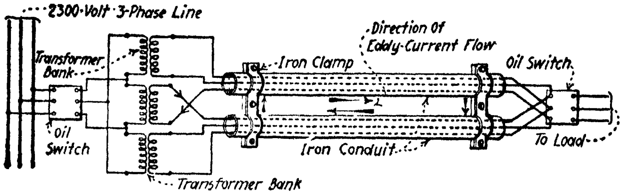



Fig. 87.—This arrangement of wiring caused heating of the conduit. The energy is transmitted through the conduits as six-wire 3-phase power. Each conduit carries both wires of one phase and one wire of another phase. Hence equal currents do not flow in opposite directions through one conduit at any instant; see Fig. 89-*I*. The conditions were remedied as shown in Fig. 88. (See *Fisher, H. D., Power, July* 19, 1921, *page* 113.)

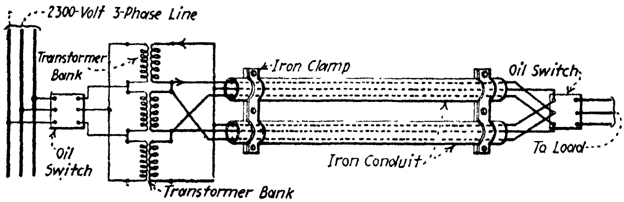



Fig. 88.—Revised connections which obviated the trouble in Fig. 87. The energy is now transmitted through the conduits as three-wire three-phase power, each conduit carrying all three wires of the system; see Fig. 89-*II*. Equal currents flow in opposite directions through each conduit at all instants and no heating is produced.

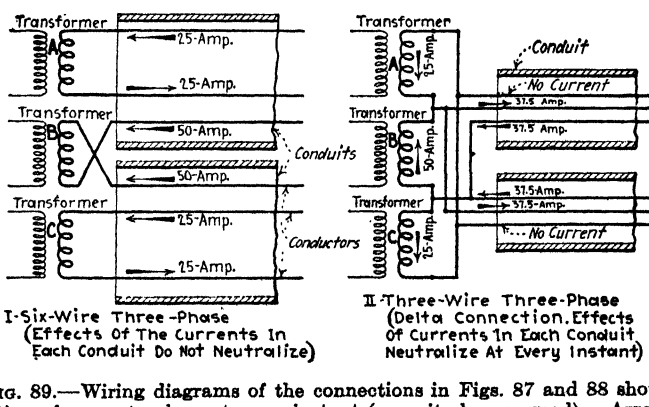



Fig. 89.—Wiring diagrams of the connections in Figs. 87 and 88 showing relation of current values at some instant (magnitudes assumed). Arrangement *I* should not be carried in two conduits with three wires each. Arrangement *II* permits the use of two conduits.

was destroyed. The trouble was overcome by connecting as shown in Fig. 88. The wiring diagrams corresponding to these two arrangements are shown in Fig. 89.

NOTE.—TO MINIMIZE EDDY-CURRENT EFFECTS, NON-FERROUS (OTHER THAN IRON) FITTINGS ARE SOMETIMES USED.—In the Essex station of the Public Service Corporation of New Jersey, brass conduit and fittings were used in numerous instances where the conduit runs were subject to the influence of intense external alternating-current fields. See Sec. 22 on aluminum conduit.

NOTE.—DIRECT-CURRENT CONDUCTORS SHOULD BE TREATED AS ALTERNATING-CURRENT CONDUCTORS when installing them in conduit wiring systems. By so doing no harm will result and the conductors need not be changed at any future time when the energy supply may possibly be changed from direct to alternating.

**81. Public Service Electric Companies Often Prescribe Rules** for the installation of service connections (Fig. 90) and

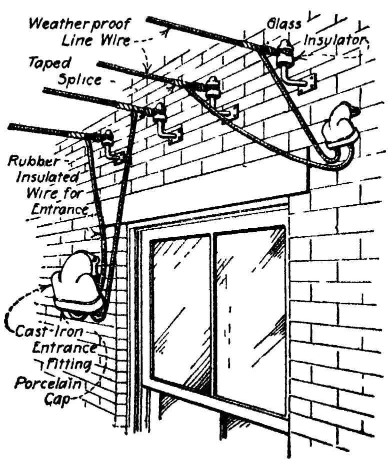



FIG. 90.—Conduit service-entrance fittings in position. (*Crouse Hinds.*)

for the placement of cutouts, switches, and meters. Before proceeding with any conduit job, the wireman should ascertain these rules and plan his work accordingly. Frequently these rules specify that the wiring shall be so arranged that, at the option of the company, either two-wire or three-wire single-phase, energy may be used in giving service to the installation. Such wiring is often termed the *three-conductor convertible system.*

NOTE.—THE WIRING FOR THE THREE-CONDUCTOR CONVERTIBLE SYSTEM is shown in Fig. 91. In the three-conductor convertible system, the interior wiring is installed by the wireman, as a three-wire system as shown in Fig. 91-*I*. The neutral wire, *B*, should in this system always have twice the current-carrying capacity of either of the outer wires *A* or *C*. (Fig. 91-*I*). Then, in the event that the public service company provides a two-wire service, it furnishes and connects the jumper, *J* (Fig. 91-*II*) outside the building.

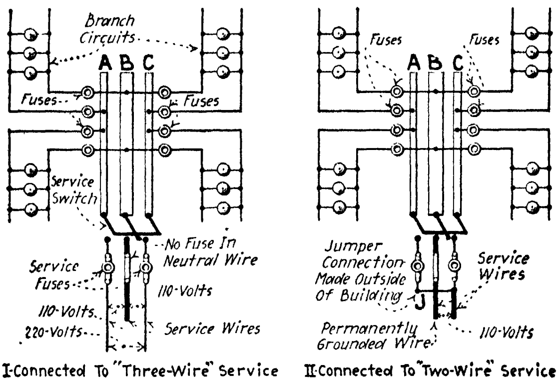



FIG. 91.—Showing connections from service mains to a panel box designed for a three-conductor convertible system. Since in *II* conductor *B* must carry twice as much current as must either *A* or *C*, it must have twice the current-carrying capacity. (See "National Electrical Code.")

**82. When Conduit Runs Are Not Shown On Plans, The Wireman Must Determine The Most Economical Runs.**—Large contractors often employ estimators who plan the conduit runs and pencil them in on the blue prints or make new tracings thereof and thus relieve the wireman of this duty. Wiremen should, however, be prepared to do this work if they should be called on. In planning the conduit runs, one is guided on the one hand by the rules under which he works (the "National Electrical Code" or some local wiring ordinance) and on the other hand by the particular requirements of the job. Refer also to the following example and to the numerous illustrations of conduit-job layouts which are given in this division. The planning of the runs may well be done by the following rule.

NOTE.—RULES FOR PLANNING CONDUIT RUNS.—The following applies only to lighting and small-device (motors less than 2 hp., small heating

appliances and the like) installations. The "Code" specifies that every motor or other device of 2 hp. or greater rating shall be served by its own individual branch circuit, the following does not apply to such large-motor and similar power installations.

(1) *Determine The Number Of Branch Circuits* that must be employed for the job. The (1923) "Code" limits—except under special conditions—the amperage and number of energy outlets on one branch lighting circuit, or other branch circuit which serves more than one energy outlet, to 15 amp. and 12 outlets respectively. Local wiring ordinances may place more stringent limits. In any case, the total amperage and number of energy outlets served through the meter or service conductors should be found. These "amperage" and "number-of-outlet" totals divided respectively by the limiting amperage (15) and by the limiting number of energy outlets (12) will determine the minimum number of branch circuits for the job. Obviously, either the amperage of each luminaire, or the number of outlets it is to contain, must be ascertained before the number of branch circuits can be computed as above, and therefore, before the conduit runs can be laid out. (See example below.)

(2) *Make A Layout For The Job.*—This may readily be done, as one proceeds, by making on the blue prints with red pencil or making a tracing on thin paper from the plans. The fixture outlet and switch locations should be accurately shown on this layout with respect to the walls and partitions. Radiator locations should be shown. The direction in which doors open should be shown. Everything should be shown which might constitute a possible interference with a switch, receptacle or lighting-outlet location. The distribution-center locations, the feeder runs to them and the branch-circuit runs can be shown out on this layout as the wiring scheme is developed, as is explained below.

(3) *Determine The Number Of Distribution Centers And The Feeder-Conduit Runs.* It is impossible to give any general rule for this. The character of the building and its occupancy, the configuration of the building, the requirements of the owner, the density of the lighting load (watts per square foot), and the economics of the situation are among the factors which should be recognized. In general, it is usually inadvisable to feed more than, say, 24 branch circuits from one distribution center or panel box. Where the lighting load is very dense it may be desirable to exceed greatly this tentative limit of 24.

In office buildings, hotels, institutions, and similar structures there should ordinarily be at least one—and sometimes several—distribution centers in each story. For any residence or ordinary small building up to 3 stories in height, 1 distribution center located centrally in the first story (or basement) is usually sufficient. For small 1- and 2-story residences and other 1- and 2-story buildings, one distribution center located centrally in the cellar (Fig. 92) or adjacent to the service switch and cut out will generally suffice. As a rule, any building exceeding 3 stories in height should have at least one distribution center in every other or in every third story.

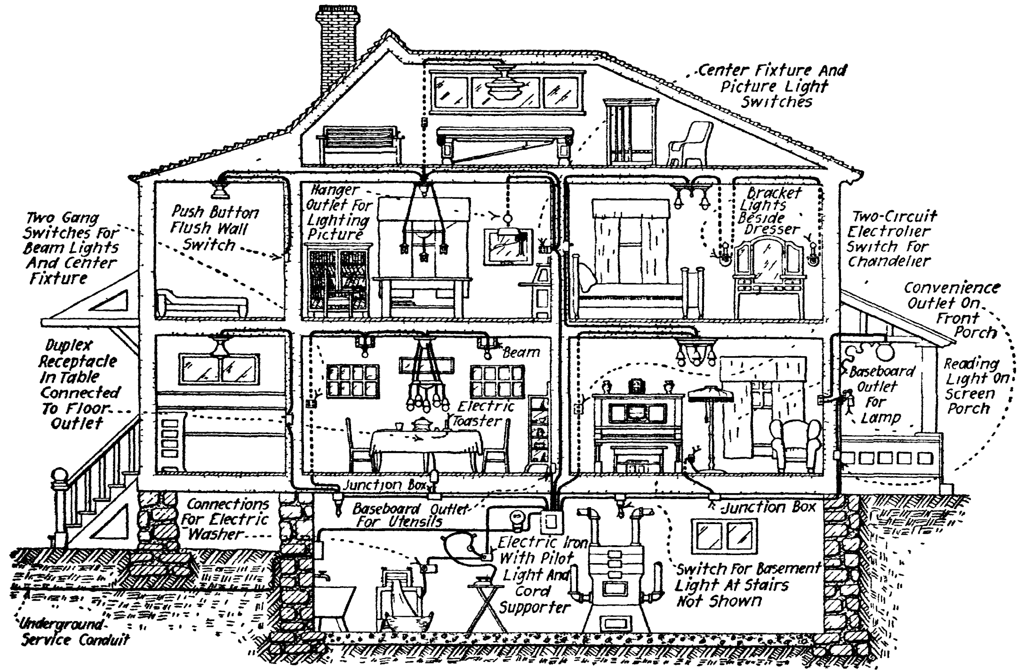
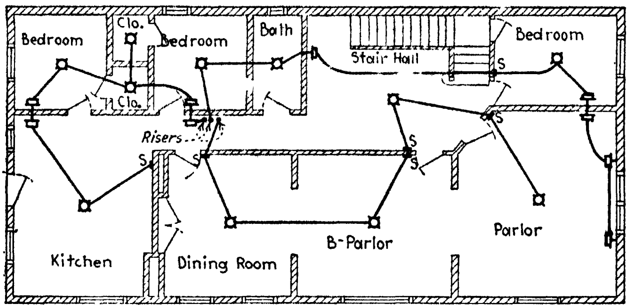
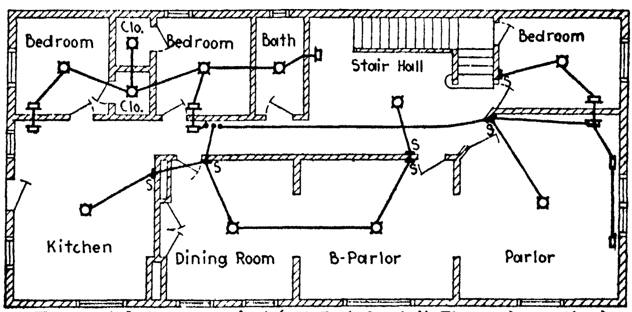



FIG. 92.—Digrammatic illustration showing conduit wiring in a small residence. This indicates the method of looping to outlets and the one distribution center in the basement. Although they are not shown in this installation, because of drawing difficulties, every modern residence-wiring job should contain: (a) *At least one two-locatiön control (three-way-switch) circuit for the hall and stairway lights.* (b) *A special electric heating circuit.* (c) *A light over the range in the kitchen.* (d) *Closet lights.*

After the number of the distribution centers has been determined and their locations shown by a rectangle drawn in on the layout, the conduit runs for the feeder from the service entrance to each distribution center—or to each group of distribution centers—is drawn in on the layout as direct a route as is feasible. The feeder conductors should be sufficiently large to carry the current without undue heating ("Code" Rule 610) and without excessive voltage drop. The feeder conduits



I-Layout A-Economical (304 Feet Conduit-$2\frac{1}{2}$ Days Time)



II-Layout B-Uneconomical (340 Feet Conduit-Three Days Time)

FIG. 93.—Efficient and wasteful conduit layouts.

should be large enough (Code Rule 503*m*) to carry the feeder conductors. The feeder-conduit runs having been thus determined and drawn in on the layout, the branch-circuit conduit runs can be planned:

(4) *Draw Tentatively The Branch-Circuit Runs On The Plans.*—Each 15-amp. or 12-outlet group of energy-consuming devices may now be connected together and to the proper distribution center by a solid line which will represent the branch conduit run. Care must be exercised to see that the energy distribution into branch circuits conforms with the rules under which the wiring is to be done.

(5) *After All Necessary Conduit Runs Have Been Shown On The Layout The Total Length Of Conduit In The Job Should Be Computed.* This may be facilitated by using a *Rotometer* or a small strip of paper or card-

board (Fig. 95) which has been graduated to the same scale as that which was used for drawing the layout. The lengths of horizontal runs of pipe may be readily scaled from the tracings. To these must be added the lengths of the vertical rises and drops. The length of wire required may be computed at the same time as the length of conduit; the number of wires in a conduit is often designated by short lines across the conduit-run line (See Fig. 96).

(6) *Select The Most Economical Conduit Routings.*—After several seemingly desirable layouts have been made and the length of conduit and wire required by each have been found, it becomes a simple matter to select that layout which requires the least conduit and wire. The layout which requires the least conduit and wire will generally also require the least labor for its installation. The value of making several layouts is shown by Fig. 93.

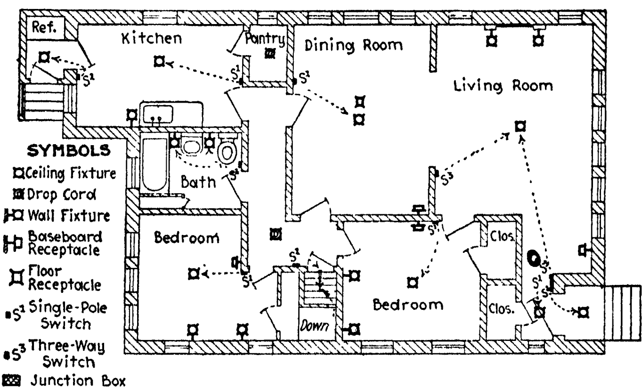



FIG. 94.—First-floor plan of a small residence showing (approximately) the locations of all electric outlets.

NOTE.—VALUES GIVEN IN THE FOLLOWING EXAMPLE ARE BASED ON THE REQUIREMENTS OF THE 1920 "NATIONAL ELECTRICAL CODE." The material was prepared prior to the issuance of the 1923 "Code." In the 1923 "Code," the maximum number of energy-consuming *outlets* (not sockets) permitted on a branch lighting circuit is 12, and the maximum load is 15 amp. Hence, although this example is based on the 660-watt and the 16-socket provisions of the 1920 "Code," the principles which are illustrated herein and the same method of solution are applicable to installations made under the 1923 "Code" rules. See the authors "Wiring For Light And Power" for a full discussion of the 1923 "Code" requirements.

EXAMPLE.—(This example is for a small residence which requires but one distribution center but the principles which it illustrates will hold for all jobs, regardless of size.) Suppose that it is required to plan the conduit runs for the small residence, the first-floor plan of which is shown in Fig. 94. The basement of this residence is to be fitted with drop cords

one of which is to be controlled by the switch, *E*, at the head of the stairs. The ceiling height in the first story shall be 9 ft. The conduit may be run exposed in the basement. The wiring is to conform to the requirements of the "National Electrical Code."

First, the wattages to be served from each energy outlet are estimated and are shown near the outlet as indicated in Figs. 96 and 97. The total number of sockets to be served is 30, and the total wattage is 1,450. Now, although 30 sockets could be carried on two circuits without exceeding the maximum number (16) specified by the "Code," the total wattage exceeds that (2 × 660 = 1,320 *watts*) which is permitted on two branch circuits. Hence, at least three branch circuits must be employed.

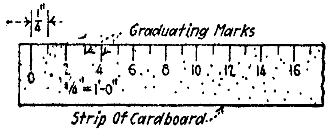



FIG. 95.—Homemade scale (¼ in. to the foot) for measuring length of conduit runs and like quantities. (The distance between the graduating marks should, for any set of plants, be made equal to the distance used on those plans to represent 1 ft.)

Tracings (Figs. 96 and 97) are sketched from the building plans and all outlets are shown in their respective places thereon. It is decided to locate the one distribution panel box, *P*, as shown in Fig. 96.

The conduit runs are laid out, (for a first trial) as shown in Figs. 96 and 97. By scaling from Figs. 96 and 97, it is found that there will be required 102 ft. of conduit in the basement ceiling and 93 ft. in the horizontal runs in the ceiling and the walls and partitions over the first

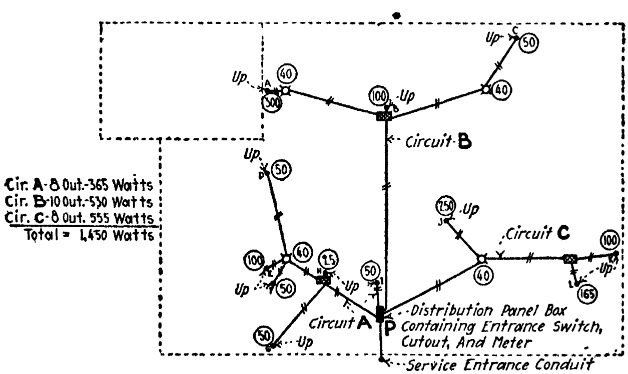



FIG. 96.—Plan of conduit runs in basement ceiling (exposed) of the small residence of Fig. 93. All conduit ½ in., all wires No. 14 B. & S. gage. The values in the circles indicate wattages.

floor. Furthermore, there will be required 9 risers extending from the basement ceiling to the first floor ceiling—about 10 ft. each, or 90 ft. in all. There will also be required: (*a*) 3 risers from the basement ceiling to wall brackets each about 6½ ft. long (3 × 6½ = 19½ ft.); (*b*) 2 drops from

the first floor ceiling to switches, each about 5½ ft. long (2 × 5½ = 11 ft.); (c) drops from the ceiling to wall brackets, each about 4½ ft. long (2 × 4½ = 9 ft.); and (d) 5 risers to base and floor outlets, each about 1½ ft. long (5 × 1½ = 7½ ft.). Hence, for this layout, *the total length of conduit required* = 102 + 93 + 90 + 19½ + 11 + 9 + 7½ = 332 *ft.* Allowing about 8 ft. for the service drop, (vertically downward from the service fitting, Fig. 90) there will be required in all about 340 ft. of ½-in. conduit.

About 50 ft. of the conduit will carry 3 wires and about 4 ft. will carry 4 wires; the remainder will carry but two wires. Hence the *total length of wire will be about:* (340 × 2) + 50 + 8 = 738 ft. Since 1,420 watts represents a current from a 110-volt main of only 1,420 ÷ 110 = 12.9

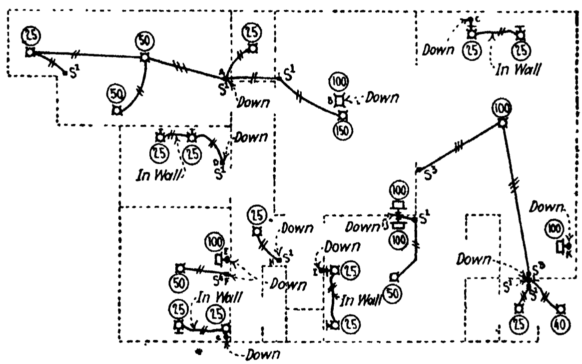



FIG. 97.—Plan of conduit runs in ceiling of first story (concealed) of the small residence of Fig. 93.

amp. (at 100 per cent. p.f.), no wire, except for the service, need, in this job, be larger than No. 14 B. & S. gage, which will, in accordance with Code Rule 610*d*, safely carry 15 amp. when the insulation is rubber. Local-wiring or public-service-electric-company rules will require the installation of service entrance wires larger than No. 14.

If several other similar layouts are made for this job and measured it will be found that that shown in Figs. 96 and 97 is as economical as any. Hence this layout should be adopted.

**83. When Building Plans As Furnished By The Architect Show Conduit Runs,** it should be determined whether any conduit and wire could be saved by routing the conduit in a slightly different manner than that which is shown on the plans without altering the circuits in any way. The building plans sometimes show the conduit runs all parallel to the principal or wall lines of the building. If the job is one of exposed conduit (Div. 6), the runs should generally be placed

parallel to the building walls lines. But where the conduit is to be concealed, the runs may, provided they do not interfere with members of the building structure, take any direction whatsoever and savings may be effected by planning to run the conduits along the shortest paths.

NOTE.—CONDUIT RUNS CAN NOT ALWAYS BE ROUTED BY THE MOST DIRECT PATHS. As suggested above, members of the building may interfere. In wooden-construction buildings, where the conduit run is at right angles to the joist length, flexible conduit may readily be drawn through holes bored through the joist centers, which holes do not materially weaken the joists. Rigid conduit is also sometimes run in this way as is explained in Sec. 183. But usually, where rigid conduit is used in frame buildings, it is laid in slots cut in the joist edges. Such cutting does materially weaken the joists (Sec. 183).

**84. The Quantities Of Materials For A Conduit Job** should be determined. This may be done by going over the drawings which show the conduit layout and listing from them all of the boxes or fittings, accessories, switches, and the like which will be required. If the quantity of conduit and wire needed has not previously been determined, this should also be found from the plans.

NOTE.—WHILE DETERMINING THE QUANTITIES OF MATERIALS REQUIRED, IT IS WELL TO WATCH FOR EXTRAORDINARILY LONG CONDUIT RUNS. Runs with more than 4 *right-angle bends*, or the equivalent, are not permitted by the "Code." Although no maximum length of straight run is specified by the "Code," runs of greater length than 100 to 125 ft. should generally be avoided. The installation of pull boxes or fittings at proper intervals will correct both of these difficulties. The time and trouble saved by having not more than 4 right-angle bends in a run and by eliminating the longer runs, will make the installation of the *pull boxes* or *fittings* profitable.

**85. In Selecting The Materials For A Conduit Job,** the object should be to ascertain what materials suit the requirements of the specifications, then determine which, if any, of these would be the easiest for the wiremen to install and the prices of the usable materials. It may happen that it will pay to use certain materials which are of higher price than some usable materials, simply because those of the higher price are the easier to install. Likewise, in some cases it will

be cheaper to let the wiremen spend a little additional time in installing materials which are very low in price. In the selection of materials experience is the best teacher.

**86. The Storage Of Tools, Materials, And Supplies** should be given consideration before a job is started. On large jobs

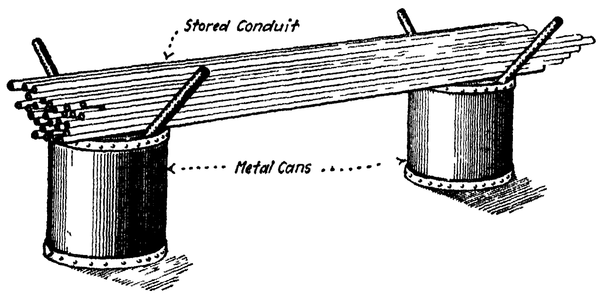



FIG. 98.—An improvised pipe rack; wooden barrels or boxes may be used instead of the metal cans.

it often pays to erect a frame room or "shanty" for the storage of the electricians' goods or to arrange to share a larger shanty with the other contractors. When the installation is in a finished building, or after a new building has reached a certain stage of completion, a room can generally be obtained and

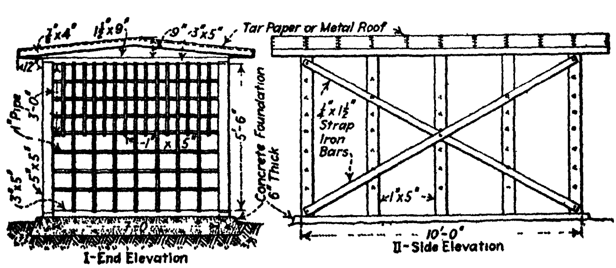



FIG. 99.—Storage shed for conduit.

the shanty is not needed. The conduit and boxes are often stored in a rack (Fig. 98) or in piles at some convenient point on the job, inasmuch as the loss of these goods by theft is not very likely to be very great, but the wiremen's tools and small or expensive supplies must generally be enclosed in a locked shanty or in a large piano box fitted with a padlock.

NOTE.—IF LARGE QUANTITIES OF CONDUIT, ESPECIALLY IF OF VARIOUS SIZES, MUST BE STORED on the job, a substantial *rack* should

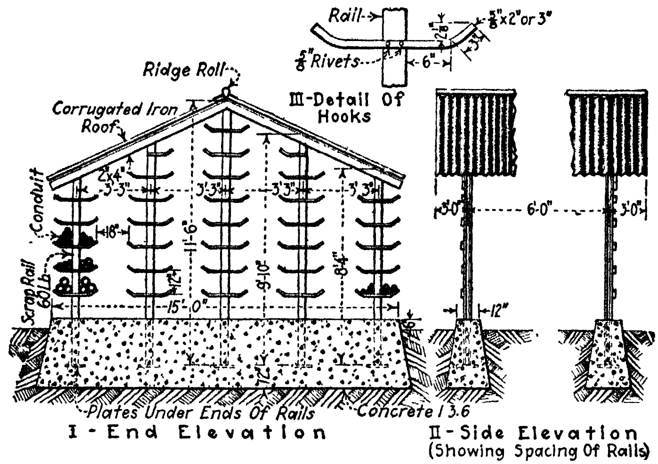



FIG. 100.—A substantial storage rack for conduit.

be built for it. If conduit is stored in the contractor's own shop or yard, a rack built of steel or of pipes (Figs. 99 and 100) is almost a necessity—

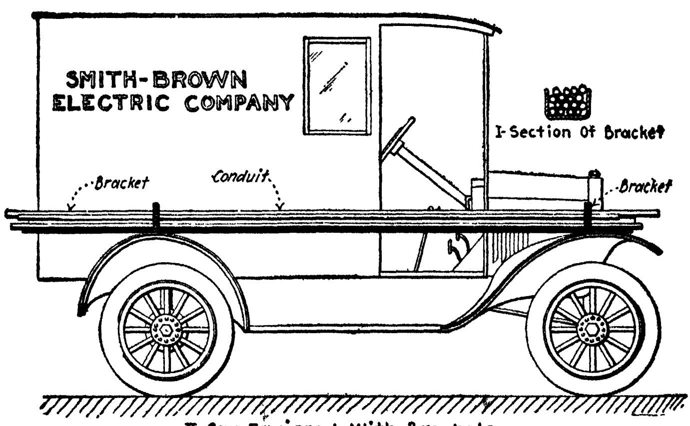



FIG. 101.—Showing a convenient means for transporting conduit.

if out of doors it should be protected from the weather. A convenient means of hauling small lots of conduit from the contractor's shop to the job is shown in Fig. 101.

**87. The First Step In The Installation Of Any Conduit Job Is To Locate, By Measurement, The Required Positions Of The Outlets.**—The exact procedure with the work is different for buildings of different construction. The wireman must watch the progress of the work on the building and endeavor to install the conduit and boxes at such time as his work will be a minimum. For instance, in a frame building, nearly all of the conduit can be installed just before the lath is to be placed on the partitions and ceilings. The partitions having been located by the carpenters, the wireman then need only to measure out the ceiling outlet locations.

NOTE.—IN INSTALLING CONDUIT IN TERRA COTTA AND IN REINFORCED-CONCRETE BUILDINGS, however, a portion of the conduit must be laid as the floors are being made. All conduit which passes up into the floor and up out of it, together with all that is to lie horizontally in the concrete (or in the tile), must be placed before the concrete is poured. Conduit in columns must also be placed before the pouring of the concrete. See Div. 5 for further information.

**88. Partition Locations Must Often Be Determined Before Placing Outlet Boxes** in terra cotta and concrete buildings.

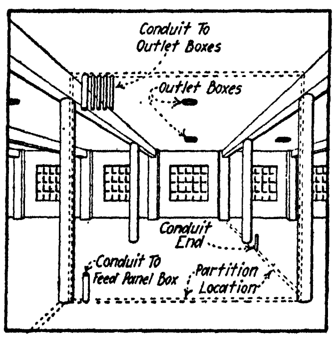



FIG. 102.—Showing appearance of conduit in a concrete building after floors and columns are poured. Note the importance of accurately determining the partition locations.

When outlet boxes are to be placed in the partitions of such buildings, the exact partition location must be ascertained because the partitions themselves are not erected until later. The wireman should ascertain, from the architect's agent on the grounds, what points may be used as *bases* from which measurements may be taken. Frequently the center lines of

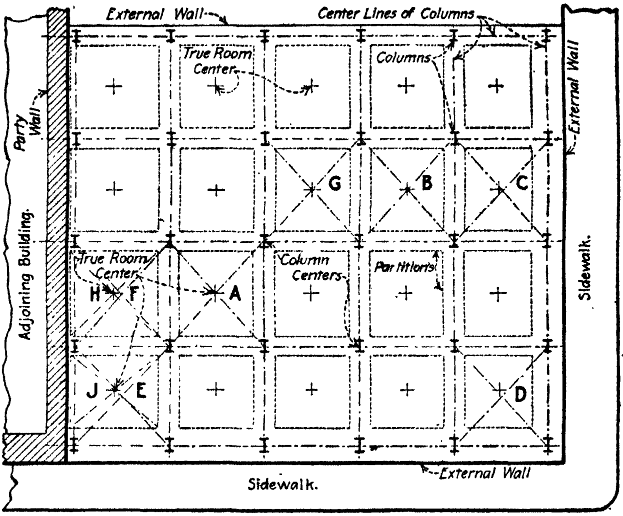



FIG. 103.—Locating ceiling outlets in office-building floor.

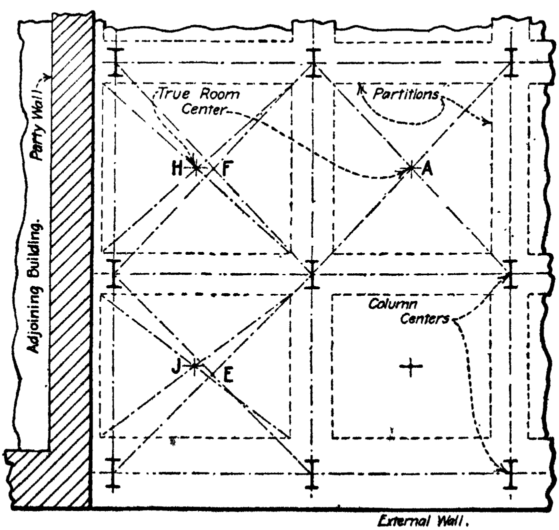



FIG. 104.—Enlarged view of a portion of Fig. 103

columns determine a partition location, but sometimes partitions are also elsewhere placed. Great care must be exercised in finding partition locations to insure that the conduit will, after the partition is located, lie within it. Failure, in this regard, may cause no end of trouble (see Fig. 102).

EXAMPLE.—A typical steel-framing floor plan is shown in Figs 103 and 104. The unequal thicknesses of walls and partitions are shown exaggerated for clearness. Where the walls or partitions are of equal

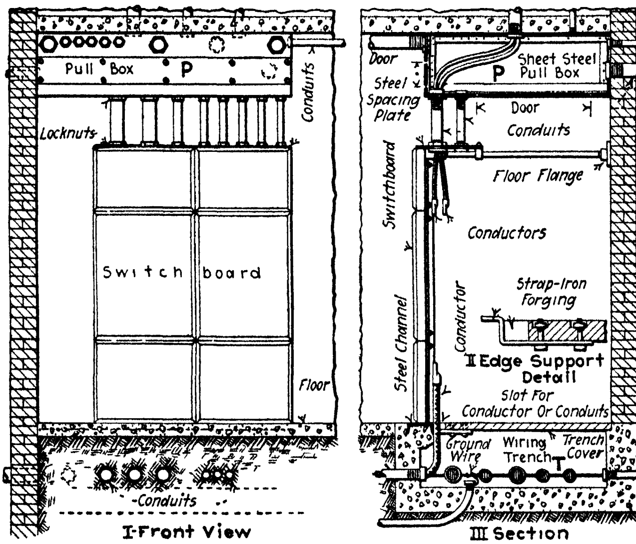



FIG. 105.—Switchboard having a pull box over it and a wiring trench under it. Unless a steel box is used to line the wiring trench or unless some similar provision is made, the ends of all of the conduits which enter the trench must be bonded together with a copper ground wire. This wire must be connected to a permanent ground or to some permanently grounded object. The switchboard metal frame must be similarly grounded.

thickness, the room centers may be established by drawing diagonals between the column centers, as at *A*, *G*, and *B*. However, where the walls on opposite sides of a bay are not of equal thickness, points located by diagonals between column centers (such as *C*, *D*, *E*, and *F*) do not give the true room centers. In such bays, the room centers must be located by first finding the positions of the finished interior wall surfaces. The true room centers may be established by drawing diagonals between the corners of the finished room, as at *H* and *F*.

**89. In Planning Conduit Wiring Around Switchboards** (Fig. 105), it is good practice to install large *pull boxes*, *P*,

above and below the switchboard. The conduit can then be run to or from the switchboard location without regard for the exact part of the switchboard to which the conduit shall deliver its conductors. All of the *cross-connecting* can be done

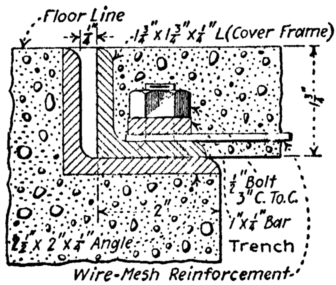



FIG. 106.—Detail of reinforced concrete trench cover and curb angle.

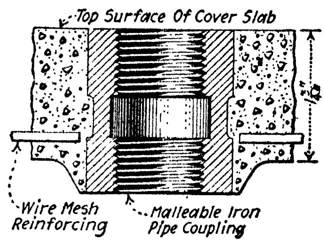



FIG. 107.—Lifting socket for concrete cover.

within the pull box. Thereby difficult and awkward-looking runs of conduit around the switchboard may be avoided. The pull box below the switchboard may take the form of a long *wiring trench* (I, Fig. 105) in the floor, either uncovered or

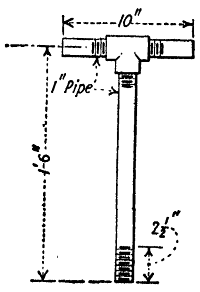



FIG. 108.—Handle made of pipe and fittings for lifting concrete covers.

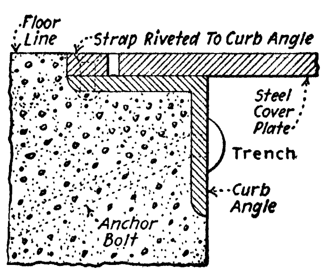



FIG. 109.—Detail of sheet-steel trench cover and curb angle. Coverplates should have 1½ in. holes in them for lifting.

covered by a steel or reinforced-concrete plate. Cover plate details are shown in Figs. 106, 107, 108 and 109. From the *pull* boxes, the conductors may be run in the open or in conduit to the switchboard. Figs. 110, 111 and 112 illustrate other installations.

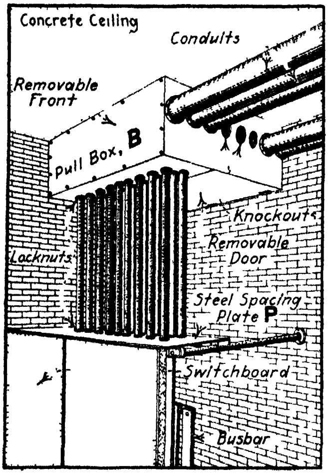



FIG 110—Pull box, *B*, and steel spacing plate, *P*, mounted over switchboard

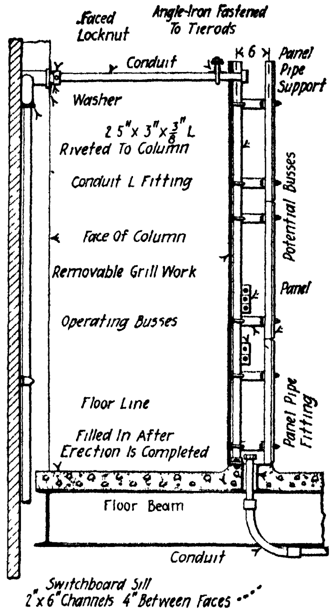



FIG 111—Arrangement of switchboard which permits the conduits to rise between two steel channel sills

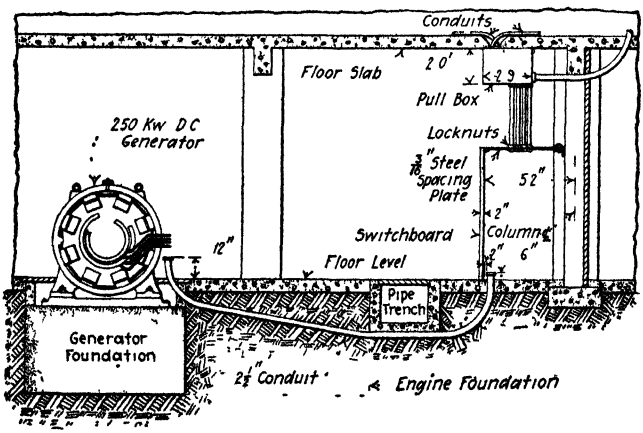



**FIG. 112.—Conduit layout for generator and switchboard Pull box and spacing plate are installed over switchboard. The spacing plate, in addition to supporting the conduit ends, grounds them to the switchboard steel frame which is itself grounded.**

NOTE.—PRESSED-STEEL WIRING TROUGHS FOR SWITCHBOARDS (*T* and *T*, Fig. 113) are described in an article by W. S. Jones in *Power* for June 27, 1922. With these, the conduits may be properly lined up, permanently secured in alignment and effectively bonded together and *grounded.* The arrangement also provides a place for carrying the small wiring (such as instrument leads) and other cross-connections from one panel to another. The steel frame of the switchboard and all conduits are

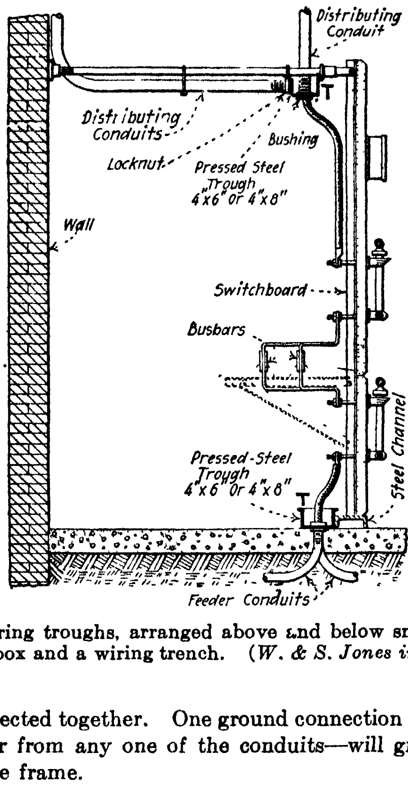



FIG. 113.—Wiring troughs, arranged above and below small switchboard, in lieu of a pull box and a wiring trench. (*W. & S. Jones in Power, June* 27, 1922.)

electrically connected together. One ground connection from the switchboard frame—or from any one of the conduits—will ground all of the conduits and the frame.

## QUESTIONS ON DIVISION 3

1. What information may the wireman expect from the plans and specifications for a small building? For a large building?

2. Show some symbols which are used on wiring plans and give their meanings.

3. Explain what happens when a single alternating-current conductor passes through a metallic body. Give the reasons why such arrangements are undesirable.

4. How may alternating-current conductors be passed through metallic bodies without harmful effect?

5. Why are non-ferrous conduits and fittings sometimes employed?

6. Is it desirable to pass single direct-current conductors through metallic bodies? Why?

**7.** Why should the wireman ascertain the rules of the public service company before proceeding with a job?

**8.** Explain, with sketches, the meaning and wiring of a "three-conductor convertible system"

**9.** When plans do not show conduit runs, who must lay them out? What forms a guide in this work?

**10.** Explain the general procedure in laying out conduit runs from building plans.

**11.** Draw an imaginary residence plan showing lighting outlets and then determine the most economical conduit runs. (Be governed by the wiring rules which are in effect in your locality.)

**12.** Need the conduit always be run as indicated on the building plans? Why?

**13.** When and how should the quantities of materials needed for a conduit job be determined?

**14.** About what length of straight conduit run should be employed as the maximum distance between pull boxes? Why?

**15.** What are the governing factors in the selection of materials for a conduit job?

**16.** State the two general methods of ordering materials for conduit work. In placing an order how should the desired article preferably be specified?

**17.** What methods are generally employed for the storage of tools, materials, and supplies during the progress of a conduit job?

**18.** Draw sketches of what you would consider convenient conduit storage racks.

**19.** What is the first step in any conduit-wiring job? What determines when this work shall be done?

**20.** When must a wireman determine partition locations? Why is extreme accuracy in this work so very essential?

**21.** Explain, with sketches, when column centers can and can not be used for determining room centers.

**22.** How may the conduit wiring around switchboards be most simply installed? Draw a sketch.

## DIVISION 4

## CONDUIT MANIPULATION AND TOOLS

**90. Before Starting Out For A Conduit Job** the workman should make such arrangements that the proper and necessary tools will be on hand at the place of installation. Generally the small tools which are the workman's own property are carried by him in a satchel. The large tools which are owned by the contractor are hauled to the installation by the contractor's wagon. In small repair jobs, when it does not pay to send a wagon to the place of installation, the workman may have to carry all the tools to the job unless he is certain that the proper tools will be available there.

**91. The Principal Tools Required For The Manipulation And Installation Of Conduit Are:** (1) *Conduit or pipe vise.* (2) *Hacksaw, or some other conduit cutting device.* (3) *Reamer.* (4) *Pipe stock and dies and oil therefor.* (5) *Pipe wrenches.* (6) *Conduit bending tools.* (7) *Plumb bob.* (8) *Rule.* (9) *Cold chisels.* (10) *Hammer.* (11) *Pliers.* The tools listed above are only those required for the installation and manipulation of the conduit and the conduit boxes. Other tools are necessary for the pulling in of conductors and the installing of the fixtures. The tools used for the latter operations will be discussed together with the operations in Div. 7. Wood tools, such as saws and bits, are often useful in installations where wooden members are encountered. The tools and the methods of using them are discussed in the sections which follow.

NOTE.—IT IS ECONOMICAL TO BUY GOOD TOOLS. The time saved and the better work obtained through their use, will in a short period pay for them. It is also desirable, when regular tools are not available, to know how to make improvised tools (for this reason some improvised tools and methods are shown in this book). Still, it should be remembered that the improvised tools are usually makeshifts and should, therefore, not be employed regularly.

**92. Upon Arriving At A Conduit Job,** one of the first things to be done is to find a suitable and convenient place to install

the *conduit* or *pipe vise.* Since the preparation of the conduit for use on the job is done at the vise, it is evident that this tool should be conveniently located. In many installations much time is unnecessarily lost because of the poor location of the vise and bench. A few minutes' time and a little forethought in selecting an economical vise location more than pays for itself in the time saved during the installation of the conduit. If a portable vise and bench are used, which is the usual practice in large installations, the location of the vise is not so important. But even the portable vise should be so located that it will not have to be moved frequently.

NOTE.—THE MOST CONVENIENT LOCATION FOR THE VISE depends on the conditions of the installation which is under consideration. In working conduit, several lengths of conduit are carried to the vise at one time, but usually each piece of conduit must be handled singly from the vise to the place of installation. Hence, the vise should, generally, be centrally located with respect to the outlets. The conduit should, if possible, be stored close to the vise. In large buildings of many floors, it may be economical to locate a vise or even several vises on a number of floors. Where much large-sized conduit is used, the cutting and threading is often done by power (Sec. 116) at the shanty. In some jobs where one portion of the conduit installation is an exact duplicate of a number of others, the portions are built up at the shanty or other convenient place. In such cases the vise is located at the same place.

**93. A Method Of Fastening A Vise To A Structural Steel Column** is shown in Fig. 114. This method may also be used for fastening the vise to a wooden column. Two holes large enough to take a ½-in. conduit, and as far apart as the width of the column, are bored in two 4- by 6-in. timbers. Then two tie rods, of the length shown, are cut from conduit and threaded. A conduit plate or a shallow pressed-steel conduit box is used on each end of each tie rod as a washer. The conduit tie rods are then inserted in the timbers, thus spanning the column, and are tightened up with ½-in. couplings. The vise can then be bolted to one of the timbers.

**94. Portable Vise Stands** (Fig. 115) are extensively used. The obvious advantage of the portable stand is that it can be readily moved from place to place as the installation progresses. This feature makes it very desirable for use in large building jobs, where, due to the size of the installation,

many stationary vises would be required if portable vise stands were not employed. For installations in large concrete

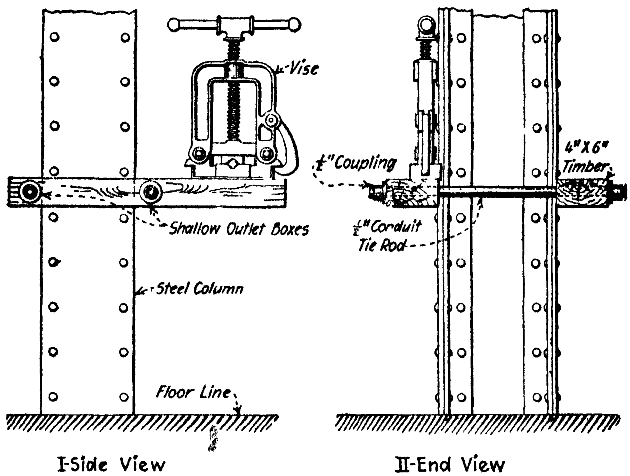



FIG. 114.—Mounting a vise on a steel column, using conduit materials and two 4 by 6 in. timbers.

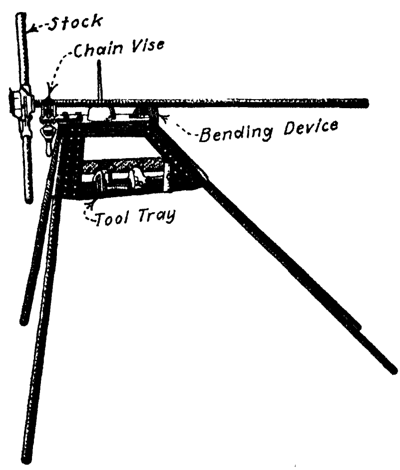



FIG. 115.—A portable vise stand for conduit work. This stand can also be obtained with a standard vise as shown in Fig. 114. (The four legs slip into sockets and can be easily removed. The total weight of the stand is 45 lb.) (*H. P. Martin & Sons, Owensboro, Ky.*)

buildings where conduit has to be laid in concrete floors, the portable vise stand is particularly well adapted. Since, in

such buildings, the columns have not been poured when a large part of the conduit is installed, a portable vise stand or bench of some sort must be used. Usually it is cheaper to use a portable vise bench which can be readily transferred from floor to floor, than to use a wooden bench which would be difficult to move or which may have to be rebuilt on each floor. In small building installations, stationary vises are usually the most satisfactory.

Note.—Most Portable Vise Stands Are As Rigid As Stationary Vises. They usually have a conduit bending device. With one type

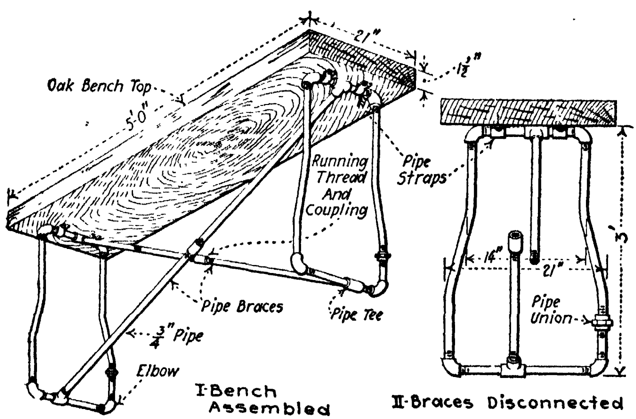



Fig. 116.—Portable and collapsible bench made of standard pipe or conduit and pipe fittings. If more stability is desired the width of the bottom of each stand may be made larger than shown.

(Fig. 115), conduit up to 2 in. in diameter can be easily cut and threaded and conduit up to ¾ in. in diameter can be bent. When cutting and threading pipe, the bending device serves as a rest for the pipe. The two front legs stand almost vertical in one plane so that they will not interfere with the stock when cutting threads.

Note.—An Improvised Portable And Collapsible Bench (Fig. 116) can be made of standard pipe or conduit and standard pipe fittings. The ends of the bench, which are constructed of pipe, elbows, and a union, are fastened to the top of the bench with pipe straps. The tees at the top and bottom of each upright are large enough to slide on the pipe. By releasing the unions or unscrewing the couplings at the middle of the braces the supports may be folded compactly under the top. A collapsible back can be fitted to the bench if desired. By using pipes proportionately larger, heavy workbenches may be made in the same manner.

**95. A Pocket Vise Is Very Convenient** (Fig. 117) for repair work or small installations, where it is uneconomical to haul a bench and pipe vise to the premises. This vise can be

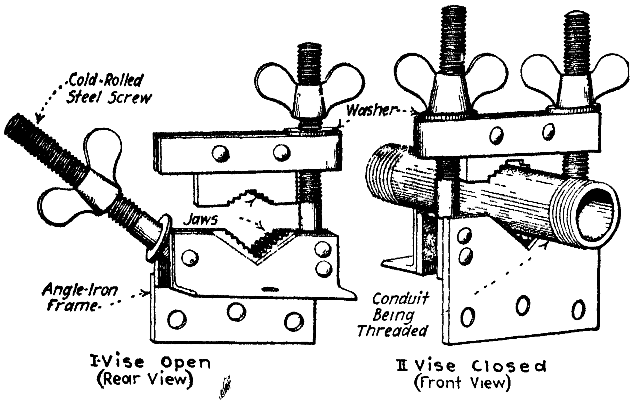



FIG. 117.—The Nye pocket vise. Manufactured by the *M. B. Austin & Company, Chicago, Ill.*

easily carried in the coat pocket or small grip of the workman. It can be securely fastened to a timber with four 10-penny

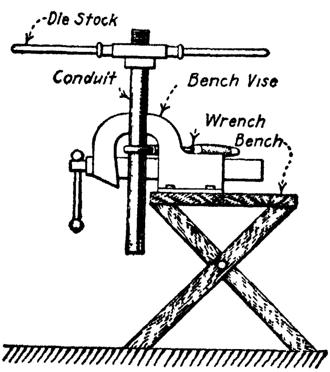



FIG. 118.—Bench vise used as pipe vise by employing a Stillson wrench to prevent turning of conduit.

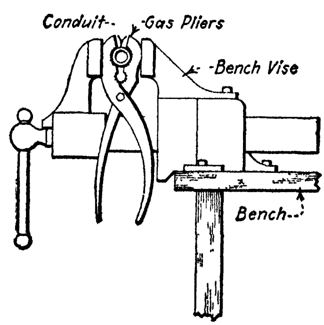



FIG. 119.—Bench vise arranged for cutting and threading small nipples. The pliers may be placed either vertically or horizontally in the machinists' vise.

nails. It can also be held between the jaws of a bench vise, thus converting the bench vise into a pipe vise.

NOTE.—WHEN A BENCH OR MACHINISTS' VISE IS AVAILABLE, OTHER METHODS MAY BE EMPLOYED FOR CONVERTING IT INTO A PIPE VISE, besides the use of the pocket vise described above. Hence, the pocket vise is not so essential where a bench vise is available. Some of the other methods are shown in Figs 118, 119 and 120. It is evident that the method shown in Fig. 118 cannot be used for long lengths of conduit. The method shown in Fig. 119 is well adapted for cutting short nipples, while that of Fig. 120 is most satisfactory for ordinary conduit lengths, provided that the vise is so mounted that the die-stock may be rotated.

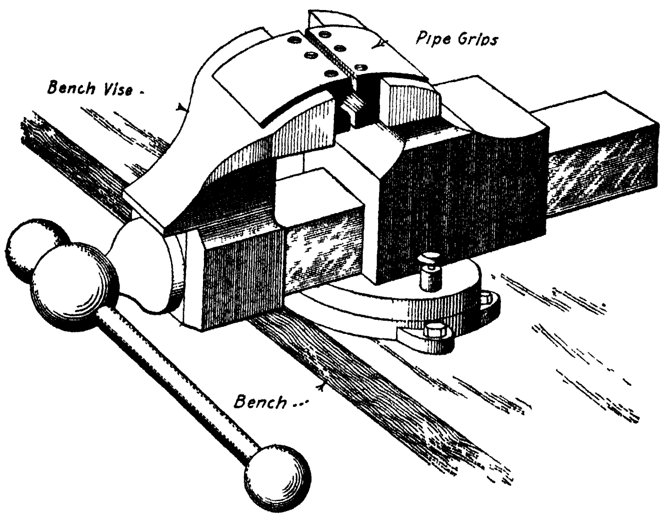



FIG. 120.—Machinists' vise, with pipe grips, can be used as pipe vise.

**96. Improvised Pipe Vises** are useful on small installations where other vises (see Sec. 95) are not at hand. The improvised vise shown in Fig. 121 is quickly assembled from materials and tools which every conduit workman has at his disposal. This improvised vise can be fastened either to a door-facing or wall (Fig. 121-*I*) or to an old table, bench, packing box, or other similar object (Fig. 121-*II*) The latter method is usually the better, since with it the conduit is supported a greater part of its length.

EXPLANATION.—All that is required is a Stillson wrench, a long conduit nipple, pipe tee or a conduit hickey, and two or three pipe straps. In the arrangement as shown in Fig. 121-*II*, the conduit to be threaded is placed on top and near the edge of the bench or table and held down

by a pair of pipe straps; if it is a long conduit, an extra strap should be put near the far end. The workman standing on the floor-pipe, prevents the Stillson wrench, and therefore the conduit, from turning. Thus, both of his hands are available for threading or cutting. Instead of its being necessary for the workman to stand on the floor-pipe, a block may be nailed to the floor to hold the floor-pipe. When the conduit is held to a wall (Fig. 121-*I*) the pipe wrench and extension handle are used as in *II*.

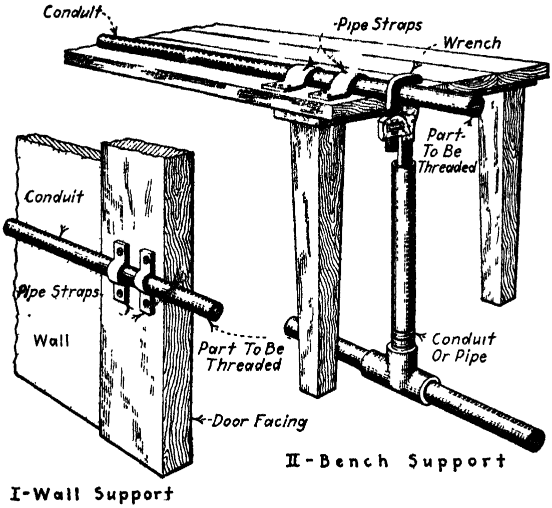



FIG. 121.—Improvised pipe vise for conduit work. A bending hickey may sometimes be used instead of the pipe tee and long nipple, for holding the wrench.

NOTE.—TO RUN A FEW THREADS ON A CONDUIT END WHEN THERE IS NO VISE OR OTHER HOLDING DEVICE AVAILABLE, place the pipe stock-and-die in a corner or recess and, using a pipe wrench, turn the conduit into the die.

**97. The Actual Required Length Of The Conduit Must Be Measured** before the conduit can be cut. Various methods are used for measuring the required length of conduit. Some are explained in the following sections. In exposed conduit wiring where conduit fittings are employed, accurate measurements are required since allowance must be made for the distance the conduit enters the fitting. In concealed conduit work where conduit boxes are used, the measurements need not be so accurate (if a locknut is used on the inside of the

box) since some leeway can be obtained within the box (Fig. 309).

Note.—A Working Sketch Is Often Desirable When Cutting Conduit for a complicated installation. Such a sketch, which should, if possible, be drawn to scale, can be made from the plans and drawings furnished for the work or from a verbal description of what is wanted, which is given by the individual who requires the work. Then after the conduit has been cut and bent to satisfy the dimensions of the sketch, the erector may be certain that it can be assembled readily on the job to form the complete installation.

**98. The Distance Threaded Conduit Enters Screw Fittings** must be considered when laying out conduit runs. This distance varies somewhat with the make of the fitting and

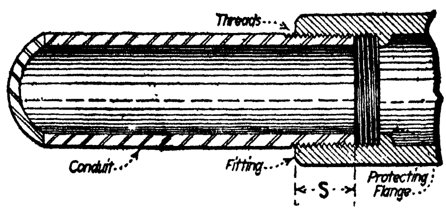



Fig. 122.—Length of threaded conduit extending into fittings.

with the actual diameter of the conduit. The conduit may not be of exactly the nominal diameter specified in the manufacturer's tables. Figure 122 and Table 99 indicate the probable fair average values. The values of Table 99 are based on the assumption that the length of thread on the conduit end corresponds with that shown in the tables of standard pipe threads.

Note.—The End Of The Conduit Should Not Be Threaded For Too Great A Distance because, if it is, it will turn too far into the fitting. Pipe threads are taper threads. Hence, if the conduit is threaded for too great a distance, the joint will not "screw up tight." In making up a conduit into a fitting, it should screw into place securely. But it should not be necessary to force it, because if it is forced a strain may be induced in the casting which will immediately or ultimately cause it to crack.

**99. Table Showing The Average Distance That Threaded Conduit Is Screwed Into Fittings.**—Some variations, due to

imperfect tapping and threading, may be expected. All the dimensions are in inches.

| D Nominal diameter of conduit | S Length screwed into fitting | D Nominal diameter of conduit | S Length screwed into fitting |
|---|---|---|---|
| 3/8 | 3/8 | 2 1/2 | 15/16 |
| 1/2 | 7/16 | 3 | 1 |
| 3/4 | 1/2 | 3 1/2 | 1 1/16 |
| 1 | 9/16 | 4 | 1 1/16 |
| 1 1/4 | 5/8 | 4 1/2 | 1 1/8 |
| 1 1/2 | 5/8 | 5 | 1 3/16 |
| 2 | 11/16 | 6 | 1 1/4 |

**100. In Taking The Measurement For A Length Of Conduit To Connect Two Fittings** (Figs. 123 and 124) the procedure is this: *First* obtain the distance, *M*, between the centers of the bodies which the conduit is to connect. *Second*, make

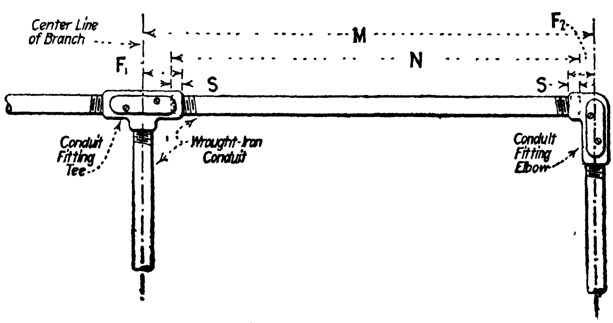



FIG. 123.—Finding the length of conduit required between two fittings.

allowance for the length occupied by the fittings and by the threaded end of the pipe which extends into them. Thus (in Figs. 123 and 124) *M* represents the distance between centers of the fittings which are to be connected. *N* shows the actual length of the conduit or nipple required. To obtain the actual length *N*, subtract from *M* the sum of the distances, $F_1$ and $F_2$, from the center to the face of each fitting

and add twice the distance ($S$, from Table 99) which the conduit will enter the fitting.

Example.—If the distance $M$ in Fig. 125 is 4 ft., the distance $F_1$ is 2½ in. and the distance $F_2$ is 1½ in. what will be the length, $N$, of a ½-in. conduit nipple to extend between these two fittings?

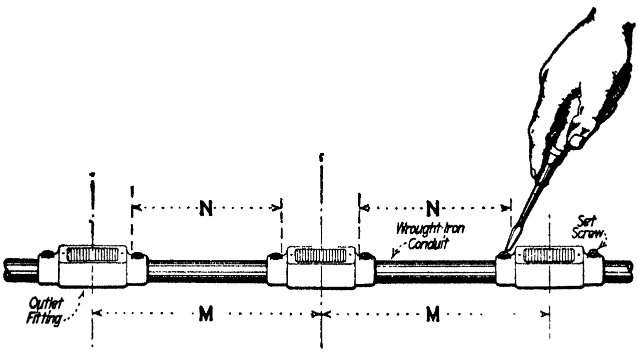



Fig. 124.—Showing how to obtain length of nipple where a number of similar fittings are spaced equidistantly along a run.

Solution.—The sum of $F_1 + F_2 = 2\frac{1}{2}\ in. + 1\frac{1}{2}\ in. = 4\ in.$ Subtracting this from the distance $M$ between centers gives the distance between faces of the fittings, thus: $4\ ft.$ or $48\ in. - 4\ in. = 44\ in.$ Now

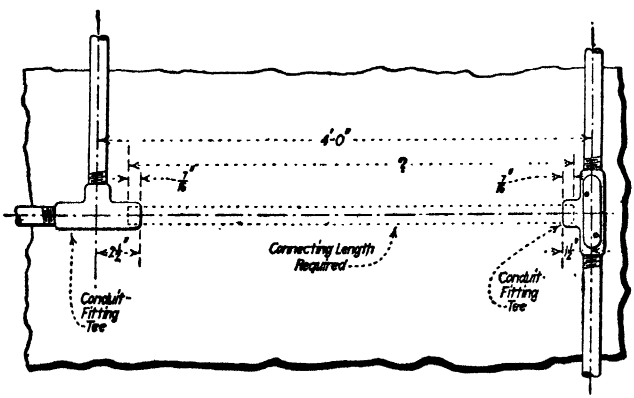



Fig. 125.—Example in finding length of connecting conduit.

add twice the distance $S$, which from Table 99 for ½-in. conduit in $\frac{7}{16}$ in., thus: $\frac{7}{16} + \frac{7}{16} = \frac{14}{16}$ or ⅞. Then, $44\ in. + \frac{7}{8}\ in. = 44\frac{7}{8}\ in.$, which is the length $N$ required.

**101. To Find The Length Of Conduit To Connect An Existing Fitting With A New Fitting, T, To Be Located In An Existing Conduit Run, B** (Fig. 126), the procedure is: First obtain the distance, $X$, from the inner end of the thread of the existing fitting (in one conduit run, $A$) to the center line of the new fitting. This may be called the "end-to-center" measurement. Then to obtain the proper length, $N$, of the nipple, subtract the distance $D$ from $X$.

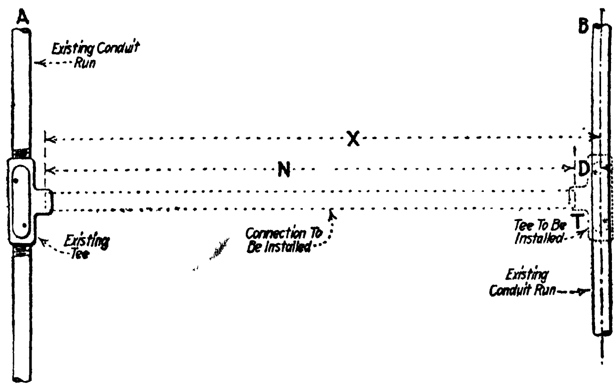



FIG. 126.—Finding the length of conduit required for a connection between two parallel runs.

**102. The Graphic Method Of Determining The Length Of Conduit Required To Connect Two 45-Deg. Fittings** is diagrammed in Fig. 127 in which $C$ is the length of the offset piece required.

EXPLANATION.—The procedure is this: First draw, either actual size or to scale, on the floor with chalk, two parallel lines, $AQ$ and $XB$ representing the center lines of the two runs to be interconnected. Now draw the chalk line $QB$ at right angles to the two parallel lines by using a steel square as indicated. Indicate on the lines $AQ$ and $QB$ the locations, $M$ and $N$, of the fitting centers. Then draw the line $AB$ through these centers. Now place the 45-deg. fittings which are to be interconnected on the floor in their proper positions on the center lines, as delineated in Fig. 127. Measure the distance $C$ between the ends of the threads in the two fittings, making proper allowance for the distance ($S$, Fig. 122) which the conduit enters into the fitting.

**103. To Compute The Length Of An Offset Piece For A 45-Deg. Offset** it is merely necessary to multiply the offset distance $O$ (Fig. 128) between the centers of the two parallel

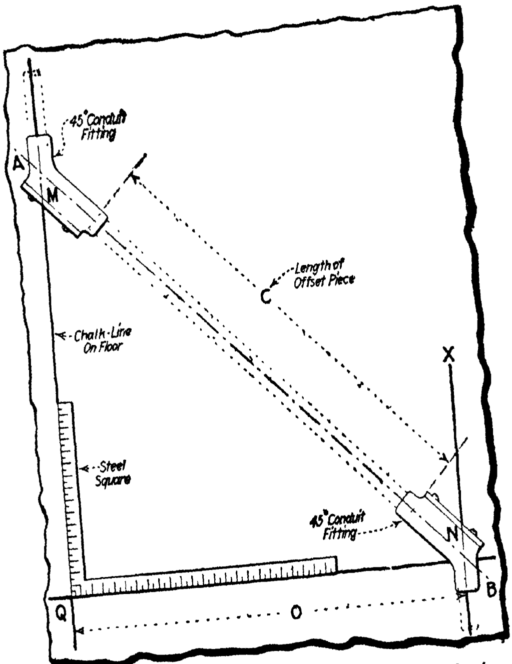



FIG. 127.—Finding length, $C$, of an offset piece by trial, by laying out fittings on the floor.

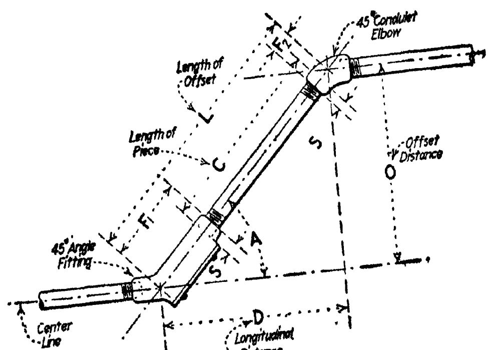



FIG. 128.—Illustrating elements involved in the determination of the length of a piece for an offset.

conduit lines which are to be joined by the *secant* (see a table of trigonometric functions) of 45 deg., which is 1.41. The value then obtained will be the length of the offset $L$. To obtain the length $C$ of the offset nipple, subtract from $L$ the sum of the distance $F_1$ and $F_2$ between centers and the outside faces of the fittings and add twice the distance, $S$ (Table 99), which the conduit enters each fitting.

NOTE.—INSTEAD OF USING THE SECANT OF 45 DEG., which is 1.4142, practical men often follow this rule: "To obtain length for a 45-deg. offset multiply the center-to-center or offset distance by 10 and divide by 7". This method is not quite as accurate as the one specified but is sufficiently so for practical purposes.

NOTE.—THE SECANTS OF ANGLES OTHER THAN 45 DEG. ARE: 60 deg. 1.15; 30 deg., 2.00; 22½ deg., 2.61. How these values may be used in *obtaining the length of offset where the offset angle is other than* 45 *deg.* will be obvious from a consideration of the preceding statements.

**104. A Small Triangle Often May Be Applied Conveniently For Locating The Center Of A Fitting Pipe Hole.**—Fig. 129

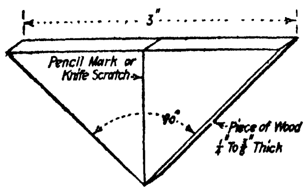



FIG. 129.—Wooden triangle used for finding center locations of outlets.

shows the details of such a triangle which can be cut from a thin piece of wood or from fiber or sheet metal. Figs. 130 and 131

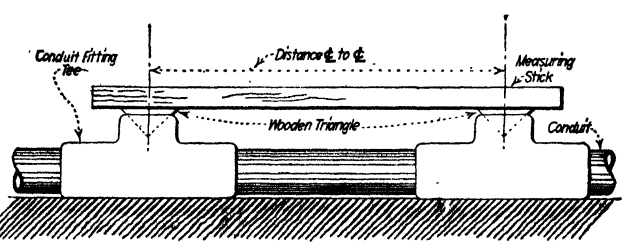



FIG. 130.—Two wooden triangles and a straight edge used for finding center-to-center distance.

show the methods of its application. To obtain the distance between centers of two pipe holes, place one of the triangles

in each of the pipe holes and measure between them as indicated in Fig. 130. This method is the most valuable where the two pipe holes are of different diameters. To find the

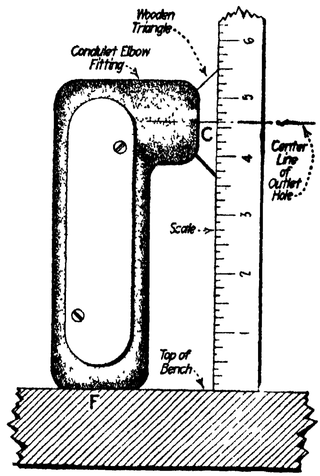



Fig. 131.—Finding end-to-center of pipe-hole distance of a condulet elbow with the wooden triangle and a rule.

distance between the face, *F* (Fig. 131), and the center, *C*, of the pipe hole of a fitting, the triangle may be utilized as diagrammed.

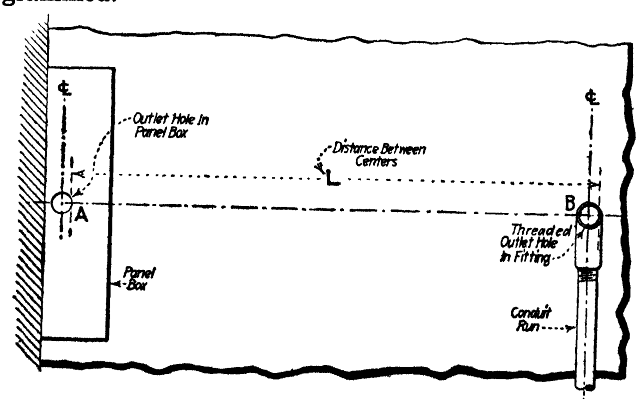



Fig. 132.—Measuring distance between centers of pipe holes.

Note.—To Obtain Directly The Distance Between Centers Of Two Round Pipe Holes Of The Same Diameter (Fig. 132) measure between the right-hand edge of one hole and the right-hand edge of the

other hole (or between the left-hand edges). Wherein the distance $L$, between $A$ and $B$ is the center-to-center distance between pipe holes.

**105. To Determine The Length Of Conduit Necessary For A U-Bend** (Fig. 133), the total length of the conduit required is obtained by adding the sum of the lengths of the two arms, $A_1$ and $A_2$, to the length of the curved portion, $BCD$. The length of the curved portion is computed by multiplying the radius, $R$, by the constant 3.141,6 or with sufficient accuracy 3.14. The measurements should be along center lines.

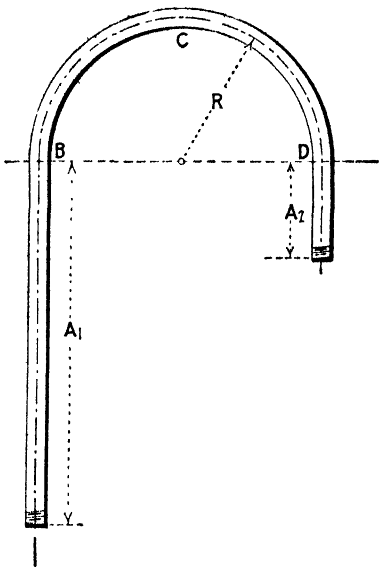



FIG. 133.—Finding length of conduit required for a U-bend.

**106. A Method Of Obtaining The Measurement For An Offset Piece Which Is To Be Installed In A Confined Space** is explained diagrammatically in Fig. 134. The method was first proposed by C. B. Hutchison in *Electrical Review* for October 7, 1914. In this illustrative example it is assumed that it is required that a piece of conduit be cut and bent to extend between the end of the pipe, $C$, which has been placed and the hole in the outlet box to be installed at $H$. Inasmuch as the ceiling space shown is only about 50 in. high, the conduit cannot be bent in it. It must, therefore, be formed in the room below and then passed, after being bent by the helper, through the outlet hole, $H$, to the journeyman who is working in the ceiling space. The journeyman working above may advise his helper below as to just how long a piece of conduit is required to fit between $C$ and $H$ and where the bend should occur in it as explained below.

EXPLANATION: A six-foot zigzag spring-joint rule may be used to determine the contour of the connecting piece required between $C$ and $H$.

The rule is adjusted until one joint, *E*, points toward the outlet box hole and one end, *D*, points toward the end of the existing conduit. The remainder of the rule is so folded that it forms a triangle, the dimensions of which are immaterial except that the base, *SE*, of this triangle must lie parallel with the surface of the ceiling. The rule having been folded as shown in the illustration, the journeyman calls out the readings at the points where the rule changes direction. Then his helper on the floor folds his duplicate rule so as to correspond with the readings which have been given to him. Now the helper knows that the vertical distance

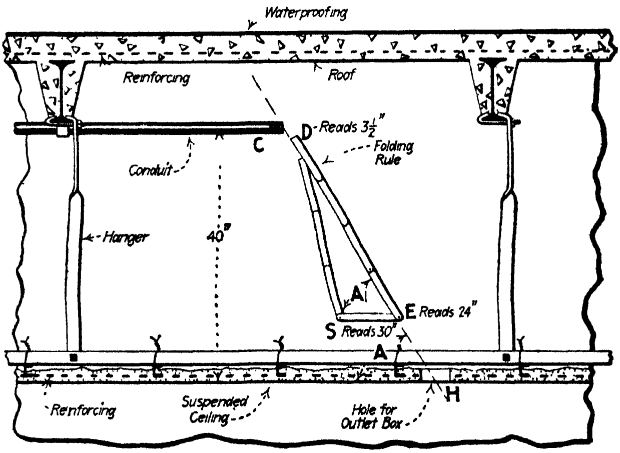



FIG. 134.—Determining, in a confined ceiling space, the angle for a bend.

between the ceiling of the room and the center of the conduit is 40 in. Therefore, he can with his own six-foot rule duplicate the angle $A_1$ and can, by making a full-size lay-out on the floor, bend the conduit so it will fit. After the helper has bent the connecting piece, he screws a coupling on the upper end of it and passes it through the outlet-box hole, *H*, for connection by the journeyman to the conduit run, *C*.

EXAMPLE—With the rule folded as shown in Fig. 134 the journeyman would call out to his helper $3\frac{1}{2}$—24—30, indicating the readings at points *D*, *E* and *S*. The helper would then fold his rule so that the triangle it formed would be a duplicate of that made by the rule in the ceiling space.

**107. To Plot Or Determine With A Two-Foot Rule The Angle Between Two Intersecting Lines** the process is this: To find the angle, *A* (Fig. 135) between the legs of the rule, open the ends so that the edges of the two legs of the rule lie along the center lines under consideration. Then measure the distance *B*. Now refer to Table 108 (which applies only

when each of the legs of the triangle on either side of $A$ is 1 ft. long) to find the corresponding angle. For example, if the distance $B$ measures $10\frac{1}{8}$ in., the angle, $A$, will then be 50 deg. Conversely, if it is desired to lay out an angle of given magnitude: Lay the rule with its sides spread apart on the floor—or on a piece of paper—and separate the ends of the legs until the distance $B$ corresponds with that given in Table 108 for the angle which it is required to plot. Two 12 in. scales or rulers may be used, instead of a 2 ft. rule, if their corners are placed together at one end.

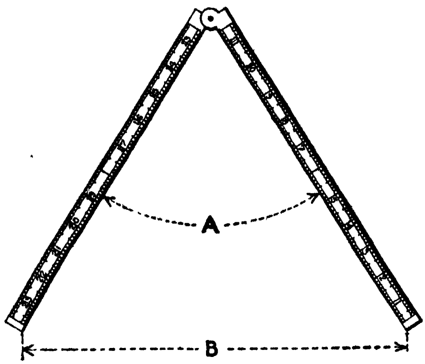


FIG. 135.—Method of measuring angles with a pocket rule.

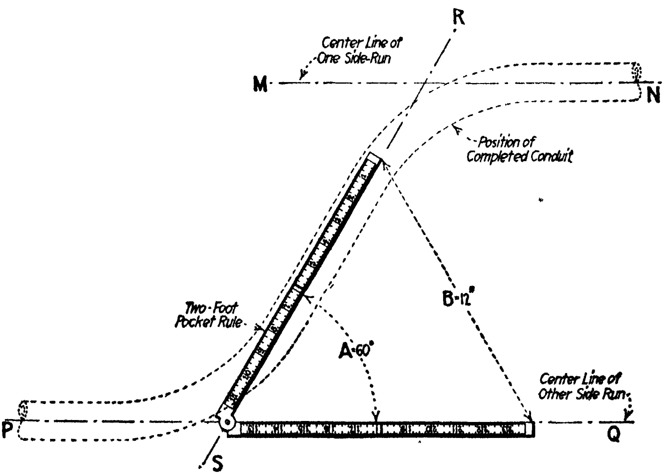


FIG. 136.—Showing how the two-foot rule may be used for measuring the angle of an offset.

NOTE.—THE METHOD OF FINDING, OR PLOTTING THE OFFSET ANGLE FOR A CONDUIT RUN OFFSET, where $MN$ is illustrated in Fig. 136. One leg of the rule is laid as shown along one side center line, $PQ$, and the other leg of the rule laid along the offset center line, $SR$. If it is desired to find the offset angle, the distance $B$ is measured and the corresponding

value is found from Table 108. If it is desired to lay off a certain angle, the process is reversed. A plot, to which to fit the conduit to be bent, may be laid out in chalk lines on the floor.

**108. Table Giving The Lengths Of B For Various Angles,** *A*, **Fig. 135.** Note that the following values apply only where the two legs of the triangle on either side of angle *A* are 1 ft. long.

| A Degrees | B Inches | | A Degrees | B Inches | |
|---|---|---|---|---|---|
| | Decimal | Nearest 64th | | Decimal | Nearest 64th |
| 1 | .21 | $\frac{13}{64}$ | 35 | 7 20 | $7\frac{13}{64}$ |
| 2 | .422 | $\frac{27}{64}$ | 40 | 8 21 | $8\frac{13}{64}$ |
| 3 | .633 | $\frac{41}{64}$ | 45 | 9.20 | $9\frac{13}{64}$ |
| 4 | .837 | $\frac{27}{32}$ | 50 | 10.12 | $10\frac{1}{8}$ |
| 5 | 1.04 | $1\frac{3}{64}$ | 55 | 11.08 | $11\frac{5}{64}$ |
| 7.5 | 1.57 | $1\frac{37}{64}$ | 60 | 12.00 | 12 |
| 10 | 2.09 | $2\frac{3}{32}$ | 65 | 12 89 | $12\frac{57}{64}$ |
| 14.5 | 3.015 | $3\frac{1}{64}$ | 70 | 13 76 | $13\frac{49}{64}$ |
| 15 | 3.12 | $3\frac{1}{8}$ | 75 | 14.61 | $14\frac{39}{64}$ |
| 20 | 4.17 | $4\frac{11}{64}$ | 80 | 15.43 | $15\frac{7}{16}$ |
| 25 | 5.21 | $5\frac{13}{64}$ | 85 | 16 21 | $16\frac{13}{64}$ |
| 30 | 6 21 | $6\frac{13}{64}$ | 90 | 16 97 | $16\frac{31}{32}$ |

**109. In Cutting Conduit,** the procedure should be as follows: (1) The length of the required piece of conduit should be

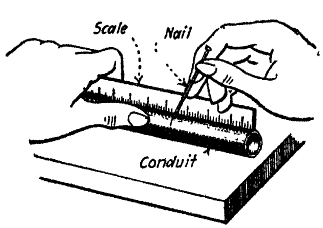



FIG. 137.—Marking a piece of conduit for cutting.

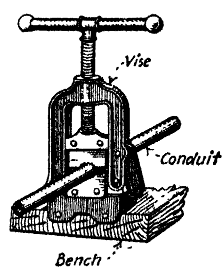



FIG. 138.—Conduit clamped in pipe vise for cutting and threading.

measured with a rule and the point of cutting marked with a knife, saw-blade or nail (Fig. 137). (2) The conduit should

be placed in a suitable pipe vise (Fig. 138) and clamped firmly therein; care being taken not to damage its surface unnecessarily by excessive pressure. (3) The conduit should be cut with either a hacksaw (Fig. 139) or a good conduit cutter (one that cuts the conduit squarely and does not leave a burr).

**110. For Cutting Small-Sized Rigid Conduit** (less than 1¼ in.), a hacksaw is generally used (Fig. 139). A hacksaw blade with about 14 teeth per in. is best suited for this purpose. In sawing, care must be taken to saw squarely through the mark and not to rock or bend the saw in cutting. As soon as the saw cuts through the first wall, the right hand holding the saw should be slightly lowered so that the saw cuts new material on the side of the conduit nearest the workman, and guides into the cut already made. The saw blade should not be allowed to hit against the sharp edge of the opposite side of the conduit as the saw teeth will probably be broken. The hand should be continually lowered or the conduit rotated until the conduit is cut entirely in two. When cutting long lengths of conduit, the free end of the conduit should be supported to avoid breaking of the conduit at the cut and making a ragged edge which requires much reaming. The sawing must not be done too rapidly as the heating effect may take the temper out of the saw blade. An application of a little lard oil will make the sawing operation much easier.

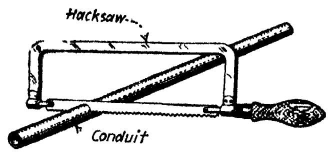


FIG. 139.—Cutting a piece of rigid conduit with a hacksaw.

NOTE.—IN CUTTING OFF CONDUIT WITH A HACKSAW (*Power*, Sept. 18, 1923; page 470), sticking and breaking of the saw blade is very likely to occur if the initial saw cut is extended clear through the pipe walls. For making a cut, first make a distinct mark all around the pipe for the length desired. Then, make a light sawcut all around, leaving the mark stand. Continue the cut to an even depth all around without cutting through the pipe walls more than necessary, until so little stock is left that the conduit end can be broken off by pressure of the hand. Some mechanics prefer using a hacksaw to any other method of pipe cutting, as the tool is light and inexpensive. When properly used it is durable, requires little effort and leaves very little burr and without deformation of the conduit. Best results are obtained when the saw blade is held in a low-back frame.

Note.—In Most Cases Conduit Cutters Would Save Time and effort (See Sec. 111) in cutting small-sized conduit, although the saving would not be as much as it is with the large-sized conduit. A ½-in. conduit can be cut with a Burrless cutter, when working at an ordinary pace, in about 40 sec. When working very rapidly, it can be cut in about 25 sec. Both figures are conservative.

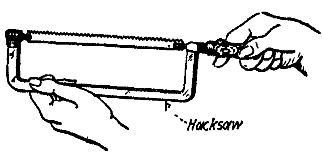



Fig. 140.—Ordinary hacksaw, showing correct method of placing the saw in frame.

Note.—In Placing The Hacksaw Blade In The Frame the blade should be inserted so that the teeth point to the front of the frame (Fig. 140). The blade should then be pulled up fairly tight in the frame to prevent the blade bending and breaking.

Note.—An Ordinary Pipe Cutter Should Not Be Used To Cut Conduit. Pipe cutters pinch the conduit and leave large burrs on the inside which require excessive reaming (Fig. 142*B*). Thus they are not desirable. For large conduit, when it is difficult to cut the conduit squarely with a hacksaw, a pipe cutter may be used to form a groove in the conduit to guide the saw. The groove can be made as deep as it is possible to make it without forming a burr (Fig. 142*A*).

**111. For Cutting Large-Sized Conduit** (1¼-in. or greater nominal diameter), special conduit cutters (Figs. 141, and 142) should be used as they will save considerable time and effort. These cutters are so constructed that they make a

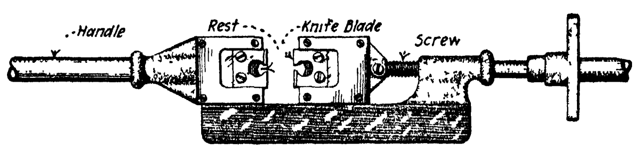



Fig. 141.—Special conduit cutter, which leaves no burr on the inside of the conduit. This type is for conduit of sizes from ½ in. to 2 in. nominal diameter. (*The Borden Company, Warren, Ohio.*)

square cut and leave a clean end (Fig. 142*A*). They do not form a burr on the inside of the conduit as do ordinary wheel pipe cutters (Fig. 142*B*). The operation of these cutters is simple and does not require the hard manual labor that a hacksaw or wheel cutter requires. All that is necessary is to turn the cutter; a compression spring feeds the cutting knives.

Note.—Power-Driven Hacksaws (Fig. 143), usually driven by an electric motor, or other power-driven saws are occasionally used to cut

large-sized conduit in big installations. When any of these power-driven saws are used, the conduit must, ordinarily, be cut at one place usually in a shanty. Power-driven hacksaws are seldom economical except in

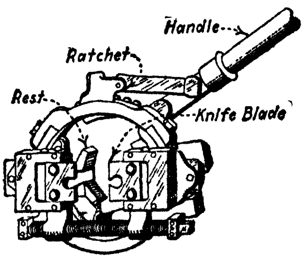



FIG. 142.—Special ratchet conduit cutter for conduit sizes, up to 4 in. nominal diameter. (*The Borden Company, Warren, Ohio.*)

installations where great quantities of large-sized conduit are to be cut and where these are then made up in sections, prior to their final placement.

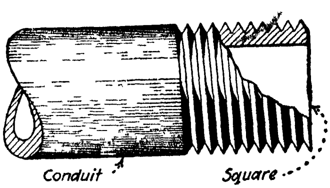



FIG. 142A.—No burr on conduit end cut by a special conduit cutter.

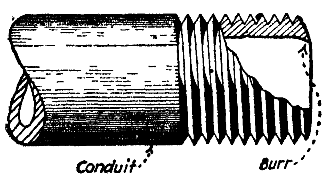



FIG. 142B.—Burr formed on conduit end by an ordinary pipe cutter.

**112. Flexible Conduit Is Also Generally Cut With A Hacksaw.** The flexible conduit should be clamped in a flat-jawed bench vise (Fig. 144) or held on a board with the foot, with the point to be cut at the edge of the board. In clamping the conduit in the vise, care should be taken not to squeeze it out of shape. Before using the hacksaw, it should be inspected to see whether the teeth are badly broken or the blade loose in the frame. A somewhat flexible saw-blade with fine teeth is best suited for cutting flexible conduit. Such teeth do not catch or break readily. The saw-cut should be started in the middle of a spiral (Fig. 145) and run straight through the conduit. Thus the square edge will be left, which is necessary in order to fit the conduit into the box connectors. Some special vises have slots to guide the saw during the cutting.

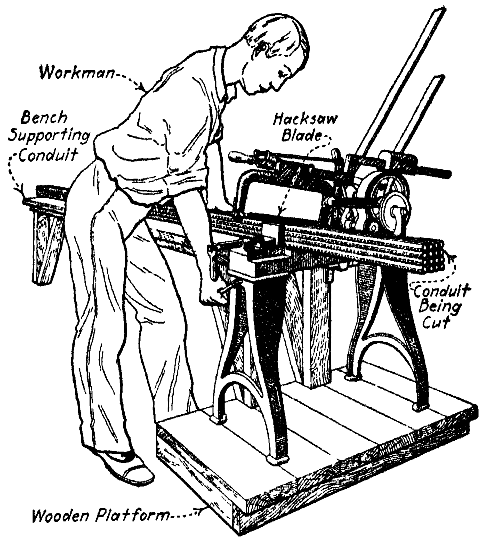



FIG. 143.—Cutting 16 ½-in. conduits at one time with a power hacksaw. (Used by Campbell Higgins of Hatzel & Buehler in the Elizabeth Plant of the Willys Corporation. *National Electragist*, Aug., 1922.)

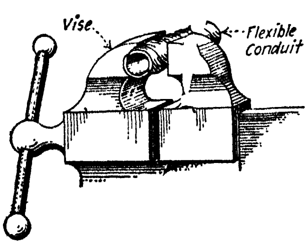



**FIG. 144.—Flexible conduit clamped in flat-jawed vise.**

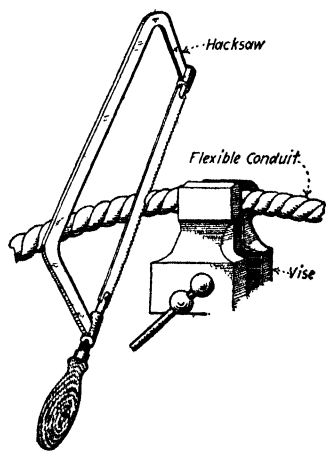



**FIG. 145.—Showing the proper method of cutting flexible conduit with a hacksaw.**

**113. The Inside Of Conduit Ends Should Be Reamed** after the conduit has been cut. This is done to remove the burr on the inside of the conduit which has been caused by the cutting. If the burr were permitted to remain in the conduit, it might cause injury to the conductors as they are being pulled into the conduit. Several types of reamers may be used for removing these burrs from rigid conduit. A burring-type reamer (Fig. 146), that can be turned by a bit brace is best adapted for small- and medium-sized rigid conduit. For conduit of the larger sizes, reamers can be obtained which


FIG. 146.—Reaming a piece of conduit.

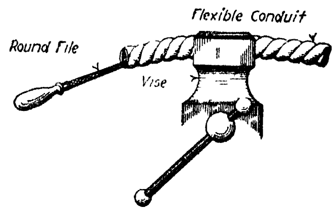



FIG. 147.—Removing the burr on the inside of flexible conduit by using a round file

have long handles or reduction gears attached, giving the needed leverage. For removing the burrs from flexible conduit, a three-cornered scraper or round file may be and is generally used (Fig. 147), since the burr resulting from the hacksaw cut is very small. Flexible conduit, before it is reamed, must be inspected to determine whether a part of the spiral strip is bent inward. If such a bend is found, it must be faced back. Then, the conduit end should be reamed carefully.

NOTE.—ROUND FILES ARE SOMETIMES USED FOR REAMING but the tapered reamers are preferable. Reamers do the work more rapidly and do not break as readily as files.

NOTE.—RIGID CONDUIT SHOULD NOT BE SCREWED TOGETHER TOO TIGHTLY IN A COUPLING, as a ridge may thereby be formed which would defeat the thing that reaming should accomplish. However, the two pieces of conduit should butt in the coupling or difficulty will be encountered when fishing the run (Sec. 243).

NOTE.—A COMBINATION "GUIDED REAMER AND THREAD CHASER" (Fig. 148) is a convenient tool when trouble is experienced with the threads of the couplings. This combination tool will ream out the end of the conduit and clean out the threads of the coupling at the same time.

Such a tool can be made by grinding down a standard tap, and forming, by means of the grinding wheel, the cutting edges at the end of the tap and at the forward end of the threaded portion. A shank for holding the tool in a bit brace can be welded onto the tap. The tool is then held and turned in an ordinary bit brace. As the guided reamer is fed in the coupling, the cutting edge at its front end first cuts out any burr which may project into the inside of the conduit. The ground down portion

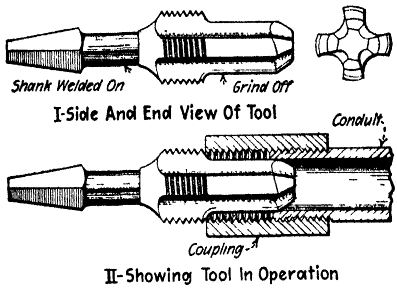



Fig. 148.—A combination guided reamer and thread chaser made by grinding down an ordinary tap.

then runs on into the conduit forming a guide. Meanwhile, the thread-cutting portion runs through the threads, cleaning them out and straightening them. When the top reaches the inner threads, the cutting edge at the forward end of the threaded portion of the tool takes hold and rounds off the inner edge of the conduit.

Note.—When A Coupling Will Not Screw On Due To Its Threads Being Damaged, reaming out the end of the coupling with a tapered reamer will usually correct the difficulty.

**114. The Threading Of Rigid Conduit Is,** for the smaller jobs, generally done by hand. For threading the smaller

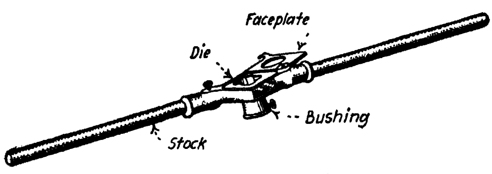



Fig. 149.—An ordinary stock and die for threading conduit.

sizes of conduit an ordinary stock and die (Fig. 149) is usually used. If properly handled, these tools give satisfactory results and do the work quickly. In cramped places, a ratchet stock and die (Fig. 150) is often very convenient. For threading conduit of large sizes ($2\frac{1}{2}$ in. to 6 in. nominal

diameter), a ratchet stock and die, which has reduction gears (Fig. 151), is often used. Such a tool is expensive but it saves considerable in labor costs since one man can operate it. These tools are portable and can be used wherever desired.

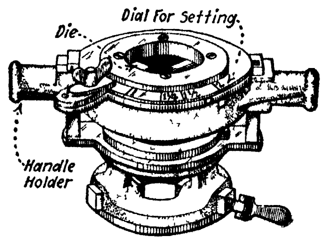



FIG. 150.—Ratchet stock and die for 1 to 2-in. conduit. (*The Borden Company, Warren, Ohio.*)

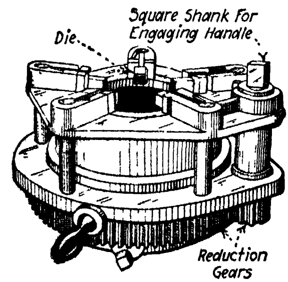



FIG. 151.—Ratchet stock-and-die, with reduction gears, for threading conduit of large size. See Fig. 155 for power-drive attachment. (*The Toledo Pipe Threading Machine Co., Toledo, Ohio.*)

NOTE.—A PIPE CUTTER MAY BE USED AS A DIE STOCK (Fig. 152). Where a die stock must be improvised this scheme may be employed. It may save carrying a separate die stock, which on a small job would be used very little. By tightening the cutters on the die, they will hold the latter firmly.

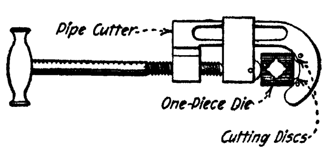



FIG. 152.—Pipe cutter used as a die stock.

**115. When Threading Rigid Conduit With An Ordinary Stock And Die,** the procedure should be as follows: Before starting to cut the thread, the die should be inspected for size, thread, and position in the stock. The bushing should also be inspected for size. If it is of improper size it should be replaced by the one of proper size. When the type of stock and die shown in Fig. 149 is used, the face plate must be secured firmly before cutting, since a loose face plate may permit the die to leave the stock during the cutting and injure the workman.

EXPLANATION.—A little oil should first be poured on the conduit. Lard oil or crude cottonseed oil is best. The stock should then be placed on the conduit until the die touches the conduit end. The stock is gripped with both hands near the die and turned slowly to the right and at the same time pushed hard against the conduit end until the die begins to cut a thread. If the stock has a leader screw instead of a bushing, the leader screw should be clamped hard against the conduit before beginning the work, and the above procedure followed except that the stock need not be pushed hard against the conduit. After the die has taken hold, the stock must not be pressed against the conduit as it will now feed forward of itself. In cutting the thread (Fig. 153), it is well to oil the die freely and rotate or "rock" the stock backwards and forwards, after every two or three turns, to break off the chips. If the die shows any tendency to jam with chips, they should be removed. When a sufficient length of thread has been cut (usually ⅞ in. to 1 in.) the die may be removed by rotating it to the left. After the die has been removed, the stock handle should be struck against the conduit to knock any loose chips from both the die and the threaded conduit. Finally, the thread should be inspected.

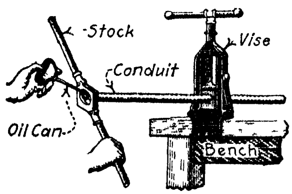


FIG. 153.—Threading a piece of rigid conduit.

NOTE.—A TYPE OF STOCK WHICH HAS ADJUSTABLE DIES IS OFTEN USED. These dies instead of being made in one piece (Fig. 149), are made in two parts. The stocks which use these adjustable dies have no face-plate, but have, instead, two screws for holding and adjusting the dies. When using an adjustable stock and die, care should be taken that the dies are properly adjusted. For proper adjustment, the line marks on the dies must coincide with those on the stock. If these lines do not coincide the diameter of the thread will be either too large or too small.

NOTE.—TO OBTAIN GOOD THREADS WITH AN ORDINARY STOCK AND DIE, experience shows that: (1) *A good die must be used.* Without a good die, which is properly designed and well sharpened, good clean threads cannot be obtained. (2) *Liberal quantities of good lard or crude cotton-seed oil should be used.* The oil cools the die and preserves its temper. It also lubricates the metals and thereby makes the cutting easier. (3) *The die must not be crowded.* If a good die is used it may be possible to run it slowly over the conduit without rocking the stock every two or three turns. But if a dull die is used the stock must be rocked after every two or three turns, if any success is desired.

**116. Power Threading Machines** are often, and with considerable economy, used on large conduit installations. How one of these machines may be used by an electrical contractor is shown in Fig. 154. The advantages are: (1)

*They are simple to operate.* (2) *They cut a better thread,* and in much less time than it could be cut by any hand-threading tool. These threading machines are particularly advantageous where duplicate sections of large-sized conduit are used. However, since they are expensive, they are usually economical only on large conduit installations. They may be used to thread conduit in the contractor's shop when sections of conduit (Sec. 92) are made up in the shop. These machines

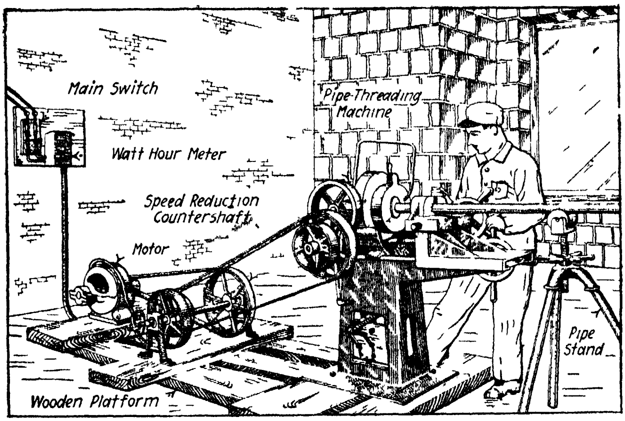



FIG. 154.—A power threading machine used on a large conduit installation. This particular machine was used to thread conduit for the Cuyahoga County Court House, Cleveland. (*The Oster Mfg Co., Cleveland, Ohio* )

also have the disadvantage of being stationary. When using them, the work must be carefully planned to eliminate unnecessary running back and forth with the conduit to see whether it fits.

NOTE.—A PORTABLE POWER DRIVE FOR THREADING TOOLS (Fig. 155) is made by the *Toledo Pipe Threading Co* , for use with its hand-operated pipe threading tools (Fig. 151). The drive consists of a 1½-hp. motor mounted on a two-wheeled carriage. The power is transmitted from the motor armature to the driving head of the device through a two-speed gearing and a shaft. The motor is started and stopped by a push-button switch located on the shaft. The transmission gears are shifted simply by pulling out or pushing in a knob which projects from a box mounted on the shaft in front of the motor. The machine weighs 231 lb., but is balanced on the wheels so that the head may be lifted and attached to the threading tool with very little effort. Being mounted on

wheels, the device automatically adjusts itself to drive a tool at any height from the floor. The power drive will cut a thread in about ¼ the time that is required by the hand-operated tool. It should be particularly well adapted for threading large-sized conduit where it is not desired to thread all the conduit at a certain location in the building.

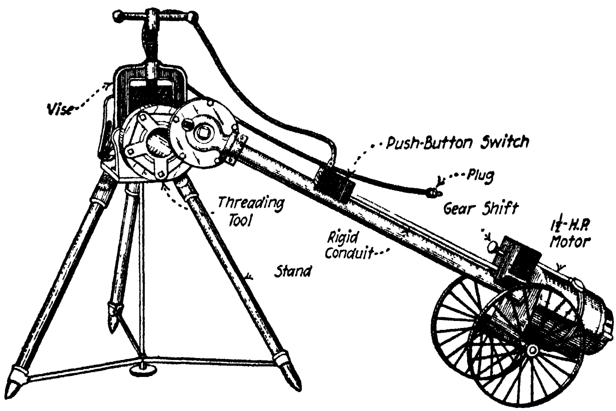



FIG 155.—Power drive for pipe threading tools. The vice may be permanently mounted on any strong bench, instead of on the portable stand which is shown. (*Toledo Pipe Threading Machine Co., Toledo, Ohio.*)

**117. Short Nipples** frequently have to be made in conduit work. In making a short nipple, the conduit to be used is threaded and cut off and the half-made nipple is screwed into a nipple holder. To thread the short nipple (Fig. 156), the standard die should be reversed (Fig. 258) in the stock. The stock is then used in this reversed position but it is, when threading, still rotated in the right-hand direction. For a guide, the next smaller size of conduit which will fit inside the nipple which is to be threaded can be used. The bushing that matches this guide should be used instead of the one that matches the die size. By placing this small guide conduit in the end of the conduit nipple which is to be threaded, and then using the stock in the reversed position a straight and close up thread can be obtained.

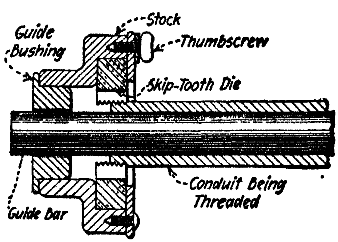



FIG. 156.—Threading a short nipple with die reversed in stock. Guide bar holds stock and die straight.

NOTE.—IN THREADING SHORT NIPPLES A NIPPLE HOLDER is required for holding the nipples after the first half has been threaded. A simple nipple holder (Fig. 157) can be made as follows: Use a piece of conduit and a coupling of the same size as that which is being used for making the nipples. Cut on this conduit a thread a little longer than is usual. Then screw the coupling on tightly. The half-made nipple is now screwed into the coupling so as to butt against the end of the holder conduit inside the coupling.

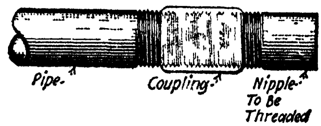



FIG. 157.—Conduit holder for use in threading nipples.

NOTE.—IT IS USUALLY MORE ECONOMICAL TO BUY SHORT NIPPLES than it is to make them. They should be made only when they can not be bought.

**118. Stillson Wrenches** are generally used for conduit installation. The Stillson wrench (Fig. 158) is better suited for most conduit installations than is the chain wrench (Fig. 160). It has the advantage that when once set for a certain

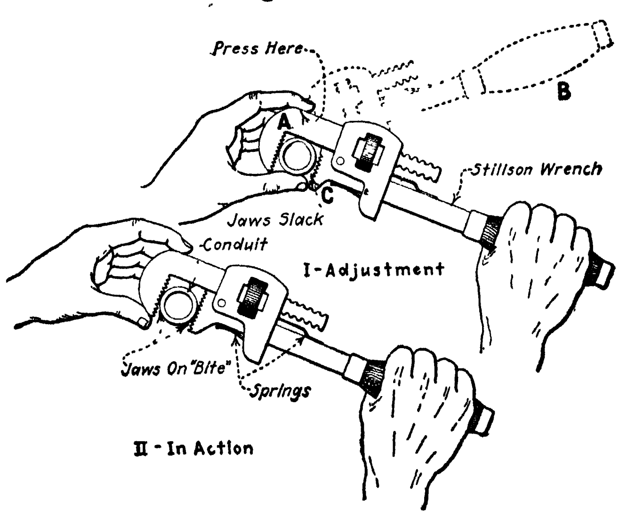



FIG. 158.—Showing how to use a Stillson wrench.

conduit size, it can be used for the size, repeatedly, without adjustment. On small-sized conduit it also affords a better grip than the chain wrench, or any other pipe wrench, and is not as awkward to handle as is the chain wrench. Thus, it is well adapted for conduit installations where large quantities of conduit of small diameter are to be installed. For

large-sized conduit or for working in cramped quarters the Stillson is not as satisfactory or convenient as the chain wrench (Sec. 120). For conduit larger than 5 in. in diameter the Stillson wrench should not be used.

NOTE.—THERE ARE VARIOUS TYPES OF SO-CALLED STILLSON WRENCHES The original Stillson wrench was of the type shown in Fig. 158. It had two exposed springs and a wooden handle. Today Stillson wrenches can be had with either wooden or steel handles. Those with the steel handles are usually preferred as the wooden handles are the more easily broken. Wrenches which operate on the Stillson principle, but which do not have any exposed springs, and which have a replaceable stationary jaw (Fig. 159) are also being made. These wrenches have the

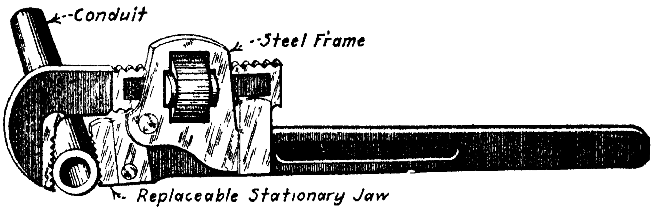



FIG. 159.—Trimo pipe wrench which has replaceable jaw. Also made with wooden handles in sizes 6 in., 8 in., 10 in., and 14 in. (*Trimont Mfg. Co., Roxbury, Mass.*)

advantage that when the stationary jaws becomes worn new jaws may be inserted; thus adding 50 per cent to the life of the wrench. The concealed helical spring on these wrenches also replaces the two leaf springs on the original Stillson type.

**119. The Proper Method Of Using A Stillson Wrench** is as follows: Adjust the wrench so that the jaws will take hold of conduit at about the middle part of the jaws (Fig. 158). To support the wrench and prevent unnecessary lost motion when the wrench engages the pipe, hold the jaw at *A*, with the left hand, pressing it against the conduit. At the beginning of the turning stroke *B*, if the jaw is held firmly against the conduit with the left hand, the wrench will at once "bite" or take hold of pipe with only the lost motion necessary to bring jaw, *C*, in contact with the conduit.

NOTE.—ALWAYS USE THE PROPER SIZE WRENCH WHEN using a Stillson or any other wrench. The different size wrenches are made to stand the strains that could be imposed on them when they are used alone. Never slip an extension pipe over the handle of a wrench to obtain a larger lever-arm in order to pull a conduit joint up tight. The increased leverage will also increase the strains in the wrench and will in

most cases bend the handle of the wrench. Use a larger wrench if a tighter joint is desired. The diameters of conduit which the various sizes of Stillson wrenches will accommodate are: 6-in. wrench, 1/8 to 1/2 in.; 8-in. wrench, 1/8 to 3/4 in.; 10-in. wrench, 1/8 to 1 in.; 14-in. wrench, 1/4 to 1 1/2 in.; 18-in. wrench, 1/4 to 2 in.; 24-in. wrench, 1/4 to 2 1/2 in.; 36-in. wrench, 1/4 to 3 1/2 in.; 48 in. wrench, 1 to 5 in.

**120. The Chain Wrench** (Fig. 160) is better suited for large-sized conduit than the Stillson wrench. It gives a

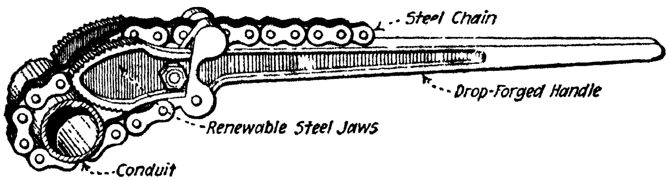



FIG. 160.—Chain wrench for large-sized conduit.

good grip and can be easily used in corners and restricted locations where it would be difficult to use a Stillson wrench. The chain on the chain wrench requires much less space than does the jaw on a Stillson wrench. It also has the further advantage that, after its chain has once been wrapped around the conduit and notched in the catch of the wrench, it will remain on the conduit until released, thus permitting the electrician to manipulate it with one hand.

**121. Improvised Wrenches** may be used for small conduit installations when there is no Stillson or other pipe wrench

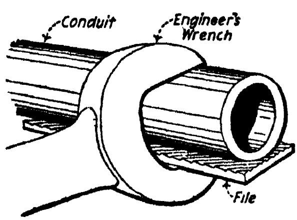



FIG. 161.—Pipe wrench improvised with flat file.

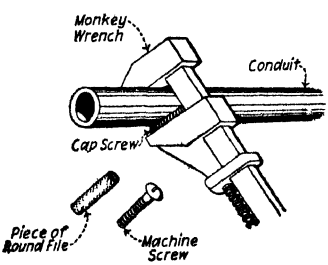



FIG. 162.—Screws used to make monkey wrench grip a conduit.

available. A monkey or open end wrench may be used as a pipe wrench as shown in Figs. 161, 162 and 163. In the method shown in Fig. 161 a flat file (preferably a taper or wedge-shaped file) is placed in the opening between the jaws

of the wrench and the conduit. If necessary it is wedged up against the conduit with a spacer. For best results the file should be inserted in the jaws a distance less than the radius of the conduit so as to obtain a good wedging action see (Fig. 166 and note below). The teeth in the file will, if adjustments have been properly made, grip the conduit firmly. In the method

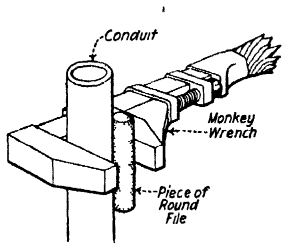



Fig. 163.—Monkey wrench and round file used as a pipe wrench.

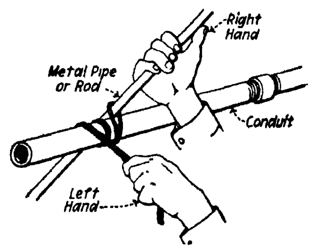



Fig. 164.—Rope "wrench" used to install conduit.

shown in Figs. 162 and 163 screws or pieces of round files are used in connection with a monkey wrench. A piece of file is better than screws as it is harder and gets a better hold. The method shown in Fig. 163, is better than that shown in Fig. 162 since in it the file wedges into the conduit (Fig. 166) in a manner similar to the action of the Stillson wrench. The

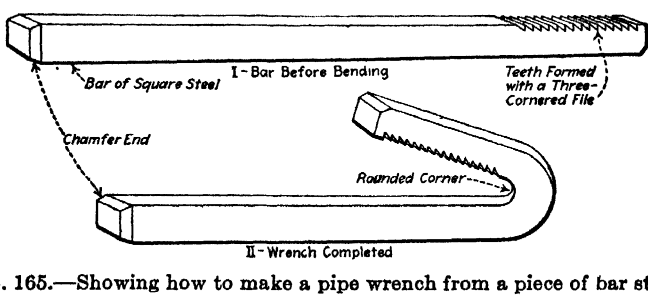



Fig. 165.—Showing how to make a pipe wrench from a piece of bar steel.

rope wrench (Fig. 164) gives a good grip and may be used to particular advantage on conduit of large diameter. A chain can be used instead of the rope. An *alligator wrench* may be made from a bar of square tool steel, as shown in Fig. 165, by filing teeth in one end of the bar and then heating and bending the bar. The teeth should be "touched up" with a file after the bending of the bar and then tempered in oil.

Note.—The Principle Upon Which The Methods Shown In Figs. 161 And 163 Operate Is Illustrated in Fig. 166. The monkey wrench, *M*, on being pulled, wedges the file or bolt, *F*, into the conduit. It is this wedging action, which is similar to that of the Stillson wrench, that makes this method grip so tight. The angle, *A*, must be made less than the angle of friction of the conduit and the bolt or file if the bolt or file is to grip the conduit. If the angle is less, the bolt or file will tend to be rolled into the jaw.

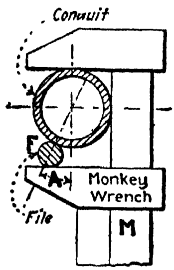



Fig. 166.—Showing how file or bolt wedges into conduit, when used in connection with a monkey wrench.

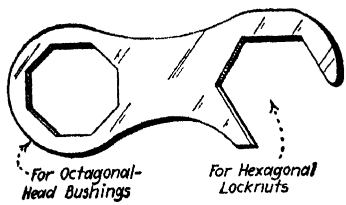



Fig. 167.—Wrench for ½-in. bushings and locknuts. (*Thomas & Betts Co.*)

Note.—A Locknut And Bushing Wrench (Fig. 167) will prove a very convenient tool. It can be used much more effectively for locknuts and bushings, particularly in cramped quarters, than can the larger and heavier pipe wrenches.

**122. Conduit Benders May Be Divided Into Four General Classes,** as follows: (1) *Hickeys,* (2) *Bending racks,* (3) *Pressure benders, and* (4) *Roll benders.* Each of these types will be defined in the sections immediately following. Examples of the different kinds of benders will subsequently be discussed in detail.

Note.—Typical Examples Of Conduit Bends are shown in Figs. 168 and 169. These indicate the contours into which conduit must be formed frequently for interior wiring installations.

Note.—Conduit Should Be Inspected Prior To Bending Or Installing (Fig. 170). Much trouble may be avoided if each length of conduit is inspected by sighting through it, before it is bent or installed.

**123. A Hickey** is a hand bender (it is really a sort of a lever) having a hole or slot at one end, wherein the conduit to be bent may be engaged. In using this tool, (Fig. 171), a portion of the conduit is held to the floor by the operator (Fig. 172),

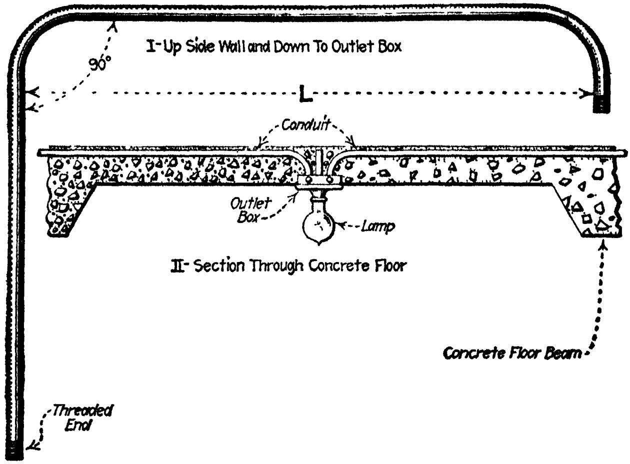



FIG. 168.—Additional examples of conduit bending.

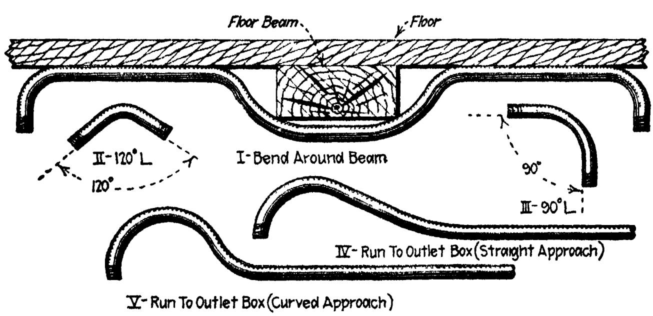



FIG. 169.—Some of the conduit bends which must be made frequently.

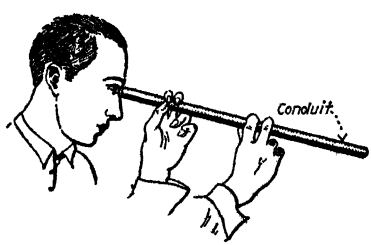



FIG. 170.—Inspecting conduit for burrs or other obstructions.

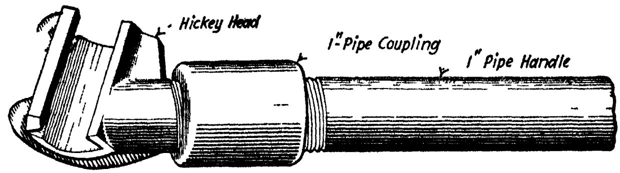



Fig. 171.—Assembled hickey. Hickey head in 1-in. pipe handle. See Fig. 181 for a hickey head. (*M. B. Austin Co., Chicago, Ill.*)

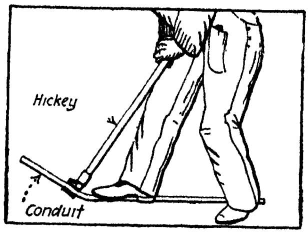



Fig. 172.—Use of hickey for bending conduit

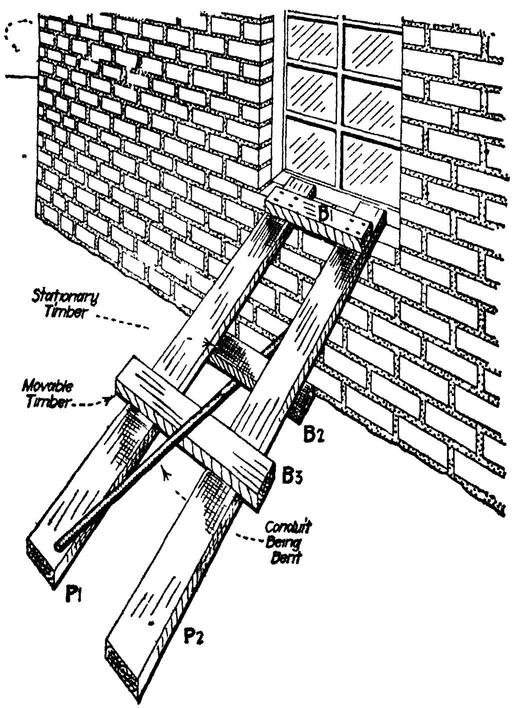



Fig. 173.—An improvised rack for medium- or large-sized conduits.

who stands on the conduit. Then, by using the hickey as a lever, the conduit, which is engaged in its lower end, is bent, by main force, into the required form.

**124. A Bending Rack** (Fig. 173) is an arrangement into which one end of the conduit is inserted and there rigidly held while force is applied to the other end to bend the conduit into the required form.

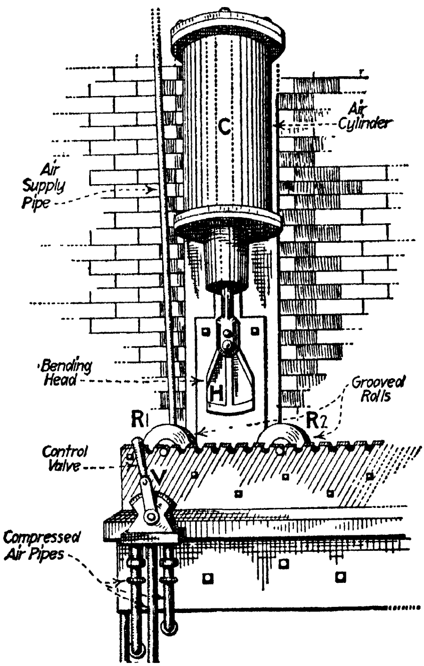



FIG. 174.—Pneumatic pressure conduit bender which was used in a railroad shop. The distance between the rolls, $R_1$ and $R_2$, may be varied for different radii bends. The bending head, $H$, is made of steel. $C$ is an air brake cylinder taken from a railroad car. $V$ is a three-way valve whereby air pressure may be admitted to either end of $C$.

**125. Pressure Benders** (Fig. 174) are those whereby conduit, particularly large conduit, is formed into curves by the direct application of pressure against the conduit (which is supported as a beam) at the location where the bend is to be made. Usually, the pressure is exerted against the conduit through a bending head or form. The pressure may, as is hereinafter explained be developed by means of a jackscrew or by a hydraulic or pneumatic cylinder or piston.

**126. A Roll Bender** (Fig. 175) is one wherein the conduit is rolled by suitably arranged bending rolls, or drawn by a rotating cam properly arranged, into the required contour.

**127. The Applications Of Each Of The Four Different Types Of Conduit Benders** are described in detail in the following sections. Briefly, they may be outlined thus: *Hickeys* are used for light work, ordinarily for conduits not greater than ½ in. or ¾ in., where it is desirable that the tool be carried to the work rather than the work to the tool. *Bending racks*

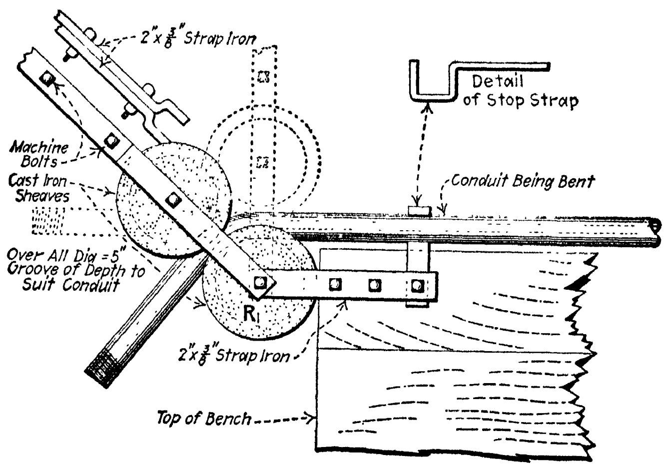



FIG. 175.—A grooved-sheave bender mounted on a bench top.

*or vises* are also used to best advantage for the conduits of the smaller diameters, but may be used, though not economically, for large-diameter conduits; with them, bends, unless they are irregular, can be formed more rapidly than with the hickeys. But the racks have the disadvantage that they must be located securely in position and that the work must be carried to them. *Pressure benders* are used for the large-diameter conduits, where it is impossible to obtain the force required for bending without some sort of a machine, and for small-diameter conduits where hydraulic or pneumatic power is available whereby the conduit may be bent economically without the exertion of manual force. *Roll benders* find their most important application for the larger-sized conduits because, with them, bends in conduits up to 4 in. in diameter

can be made uniformly and accurately, without the tubes. They are particularly advantageous where a large number of conduits are to be bent to the same contour.

**128. The Advantage Of The Hickey** is that it may be carried to the location where work is being done. Where benders of

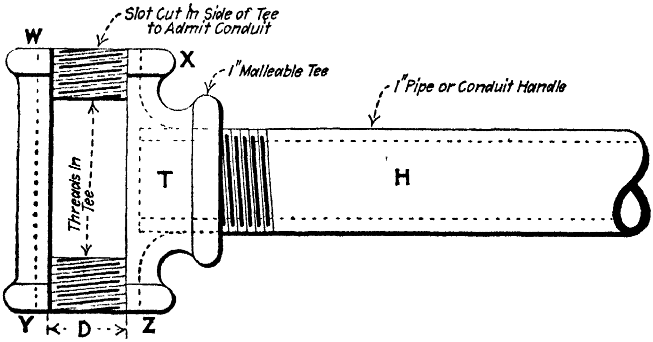



FIG. 176.—Homemade, openside hickey.

the rack, pressure or roll types are used, it is then necessary to carry the work to the bender. A wireman can carry readily, in his tool box, the head for a commercial hickey (Figs. 181 and 182), or, instead, a 1-in. or a 1¼-in. pipe tee (Fig. 176). On the job he can usually find a piece of pipe of the correct

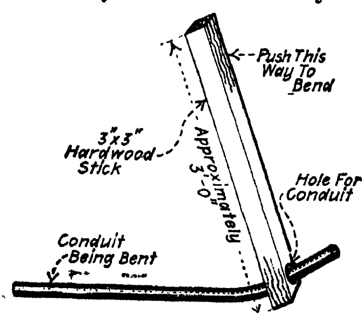



FIG. 177.—Bending conduit with a hardwood stick.

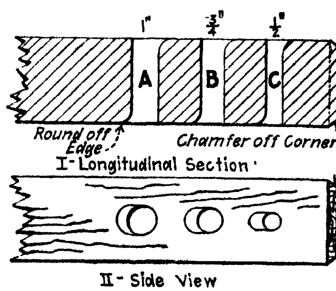



FIG. 178.—Method of boring holes in bending stick.

diameter to serve as a handle and thus assemble the complete tool. It is apparent, then, that hickeys have an important field of usefulness regardless of whether or not benders of the other types are available.

NOTE.—A WOODEN STICK MAY BE USED AS A HICKEY. In Fig. 177, hardwood stick is shown used as a bending hickey. These sticks will

not last as long as iron hickeys, since the pressure of the conduit against the wood fibers, at the sides of the holes, enlarges the holes, so that the stick will no longer grip the conduit. The holes should be bored as illustrated in Fig. 178.

**129. Pipe-Fitting Hickeys** are shown in Figs. 176, 179 and 180. These are, in a sense, improvised tools but will give quite satisfactory service until they wear out. They are, probably, the most commonly used of all hickeys. Each consists of a pipe-fitting tee, preferably malleable iron, of a size larger than the conduit to be bent. The tee is provided with a length of pipe or conduit, 3 ft. to 3 ft. 6 in. long, for a handle. A slot (*WXZY*, Fig. 176) should preferably be

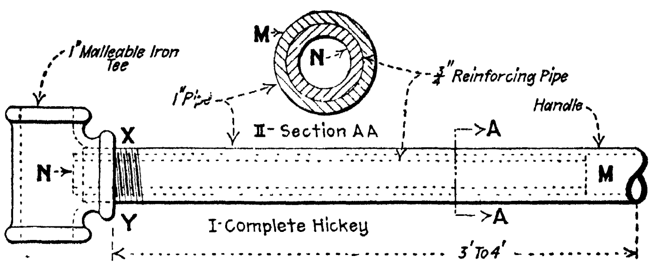


FIG. 179.—Method of reinforcing a malleable-iron tee hickey.

cut in the side of the tee. The width of the slot, *D*, should be large enough to admit easily the conduit to be bent. Then to use the hickey, the conduit to be bent is slipped through the slot in the tee and the hickey is pulled toward the operator. He, in the meantime, holds a portion of the conduit on the floor by standing on it (Fig. 172). The slot saves considerable time which would otherwise be lost in slipping the hickey on the conduit. For ordinary house work, as suggested in Fig. 179, a 1-in. tee is used.

NOTE.—THE HANDLE OF THE PIPE-TEE HICKEY CAN BE REINFORCED (Fig. 179). If the pipe handle of a hickey should break, the rupture will always occur at *XY*, where the handle screws into the tee, since this is the section of least area. A piece of ¾-in. pipe or conduit, *N*, may be driven into the 1-in. pipe or conduit handle, *M*, to reinforce this section. The end of the reinforcing piece should be about flush with the end of the handle before the handle is screwed into the tee. The ¾-in. conduit outside diameter is listed as 0.001 in. greater than the inside diameter of

the 1-in. conduit pipe. Thus it may be necessary to file the ¾-in. conduit to fit but frequently a piece can be found that will just fit.

NOTE.—SMALL-DIAMETER HICKEY HANDLES ARE OFTEN PREFERRED as they fit the hand better. Such a handle can be provided by means of a reducer, *R*, as shown in Fig. 180. Another method when a 1-in. tee is used, is to drive a ¾-in. conduit or pipe into a short 1-in. conduit or pipe which screws into the tee.

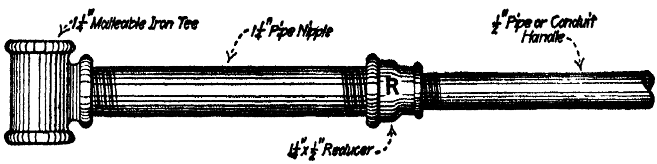



FIG. 180.—Pipe-tee hickey with working-end fittings of 1¾ in. size, and a handle of ½-in. conduit or pipes.

**130. The Disadvantages Of Pipe-Tee Hickey Heads** are that they do not grip the conduit when they become worn. When new, the threads within the tee effectively grip the conduit which is being bent, but use flattens out the threads so that they will not bite. Another disadvantage is that, since the handle is rigidly attached to the head, the tool cannot be used in restricted locations in which a manufactured hickey head with an adjustable handle (Fig. 182) can be applied.

**131. Commercial Hickeys** are of various designs and types. The two hickeys described herein are fairly representative of those most generally used. The *Lakin hickey* (Fig. 181) is merely a one-piece hickey head, inasmuch as the 1-in. pipe handle which is attached to the head by means of a pipe coupling, must be furnished by the purchaser. The *Fey Automatic-grip hickey* (Fig. 182) has a movable jaw, which, when the operator pulls on the handle, automatically clamps the conduit and prevents the tool from slipping. The handle may be moved in either direction, while bending the conduit. When moved to the limit in one direction the handle will, when the workman starts to form the bend, make an angle of about 55 deg. with the conduit; in the other direction the angle will be about 100 deg. Thus, two different starting positions for the handle are available. This permits the hickey to be used in restricted locations. The interiors of the jaws are smooth. No notches are required for gripping

the conduit, so wear on the interior surfaces of the jaws, due to bending conduit, does not affect its utility.

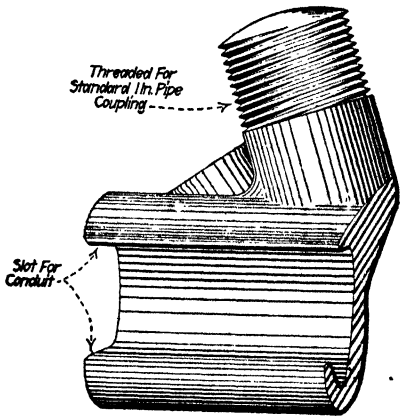



FIG. 181.—The Lakin hickey, made for ½ and ¾-in. conduit. (*Thomas & Betts Company, New York City.*)

NOTE.—THE HANDLE OF A HICKEY SHOULD NOT, UNLESS REINFORCED, SCREW INTO A THREADED HOLE IN THE HEAD. A handle may be reinforced as shown in Fig. 179. If non-reinforced construction is

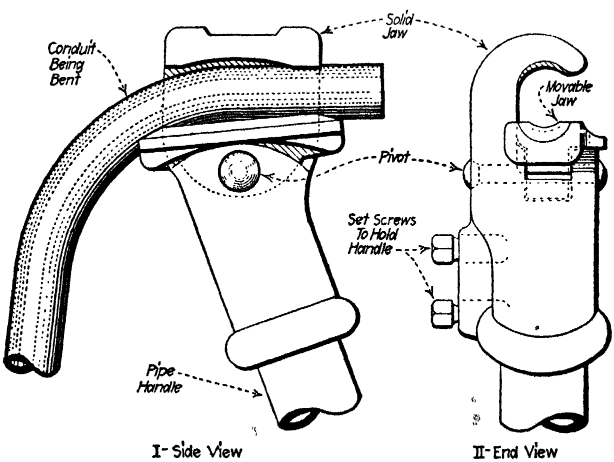



FIG. 182.—The Fey automatic-grip hickey.

used, and the handle should break off at the top of the head, it is difficult to remove the short length of pipe which will then be broken off in the head. When a coupling is used, as in the Lakin construction (Fig. 181)

and the handle breaks off, the coupling can be easily unscrewed from the head. In the Fey Automatic-grip hickey (Fig. 182) the tendency for the handle to break at the top of the head is eliminated since the handle is held in by set screws; thus it is not weakened by having threads cut in it.

NOTE.—A HICKEY IMPROVISED FROM AN IRON BAR AND A SHEAVE is shown in Figs. 183 and 184. It operates on the roll principle.

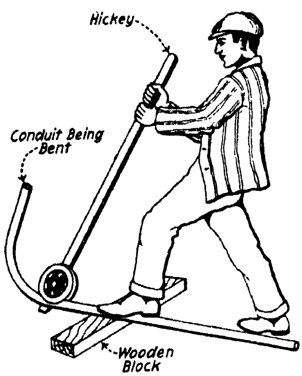



FIG. 183.—Showing how sheave bar bending hickey is used.

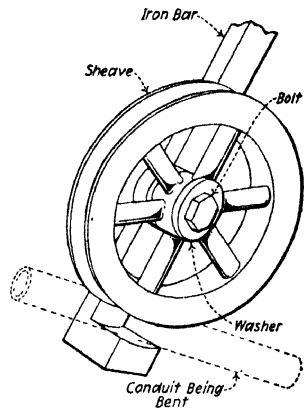



FIG. 184 —Sheave-bar bender.

**132. A Bending Rack For Large Conduits** is shown assembled in Fig. 185, while Figs. 186 and 187 illustrate details of its construction. The two longitudinal timbers, *G* and *G* (Fig. 185) should, for heavy work, be at least 6 in. square. Across the longitudinal pieces are bolted two fixed pieces, *F* and *T*, each about 6 in. square and several feet long. A movable timber, *M*, (see Fig. 187 for detail), which has a groove cut in it for the conduit, is arranged to slide longitudinally on the rack.

EXPLANATION.—When in use, one end of the rack is elevated on a box frame or saw-horse as suggested in the illustration (Fig. 185). In bending the conduit, one end is placed under the timber *F*, and *M* is shifted to the most desirable position. Then when the mechanic throws his weight on the other end of the conduit, *W*, it will produce a bend in the conduit. A bend cannot ordinarily be made with one setting of *M*. It is, on the contrary, necessary to do the thing by increments. That is, with one setting of *M* the conduit is partially bent; then *M* is shifted backward or forward as may be required and the conduit bent further. This process is continued until the desired contour has been obtained.

The movable timber, *M*, should have the slot, which is cut in it for the conduit, rounded as detailed in Fig. 187. The slot should never, except

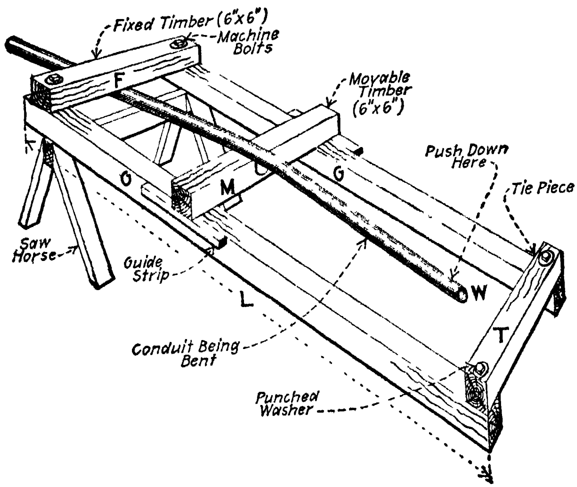



FIG. 185.—Bending rack constructed from heavy timbers. *L* may be about 6 ft. or more.

for the roughest sort of work, be cut square as shown in Fig. 186. If the slot is not rounded, there is a possibility of introducing kinks or

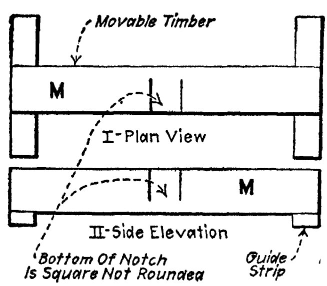



FIG. 186.—Showing the simplest but not the best method of cutting notch for conduit.

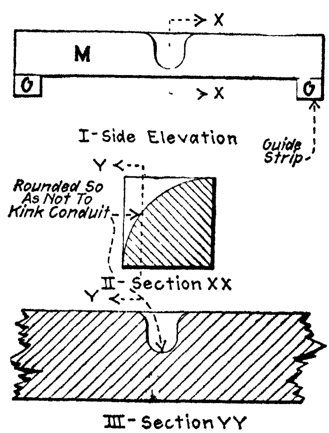



FIG. 187.—Details of movable timber of correct construction.

wrinkles into the conduit. For the best work, the width and the radius of the slot should be such that the conduit fits into it nicely. Hence,

it is desirable to use a separate movable timber, which has a groove of a different diameter, for each size of conduit. Or, instead, a number of different grooves of different sizes may be cut in the same movable timber to accommodate conduits of different diameters. However, a skilled workman can operate successfully on conduits of a number of different diameters by using a groove of but one size.

NOTE.—OTHER IMPROVISED BENDING RACKS FOR BENDING MEDIUM- OR LARGE-SIZED CONDUIT are shown in Figs. 173 and 188. The bending rack shown in Fig. 173 is similar in construction and operation to that

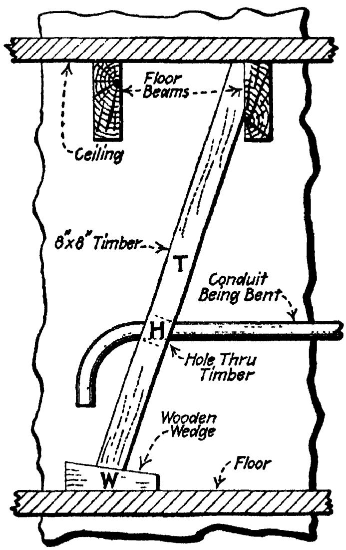



FIG. 188.—Timber braced between floor and ceiling for a bending rack.

shown in Fig. 185. It consists of two principal timbers, $P_1$ and $P_2$, and a couple of blocks, $B_2$ and $B_3$, arranged across them as indicated. It is usually desirable to nail a third piece, $B_1$, across the upper ends, to prevent the timbers from spreading. The bending rack shown in Fig. 188 consists of a timber, $T$, braced between ceiling and a floor, through which is cut a hole, $H$, large enough to admit the largest conduit to be bent. The wooden wedge, $W$, clamps the timber in place. In bending, the conduit is gripped as shown, in the hole, $H$. In order to secure sufficient leverage it may be necessary to push a length of conduit of a larger diameter over that being formed, thus providing a long handle. Usually, in bending the conduit a considerable portion of the bend is formed on one side of the timber and then the bend is finished on the other side. Two men pushing down on the end of the conduit are usually necessary for effective work. If conduit of smaller diameters is to be bent, wooden blocks may be placed in the hole, $H$,

**133. A Bending Rack Comprising Two Blocks, $B_1$ And $B_2$, Bolted On A Post, P,** is often employed (Fig. 189). A rack of this design is often useful for conduits of the medium diameters. The blocks are either spiked (or, preferably, held with lag-screws or bolts) to a wooden column or post. They should, if possible, be of hard wood—maple. The blocks may extend from 2 to 3 in. beyond the face of the post, to prevent the pipe from slipping out of place while it is being bent. A semicircular groove cut in each block close to the post, so

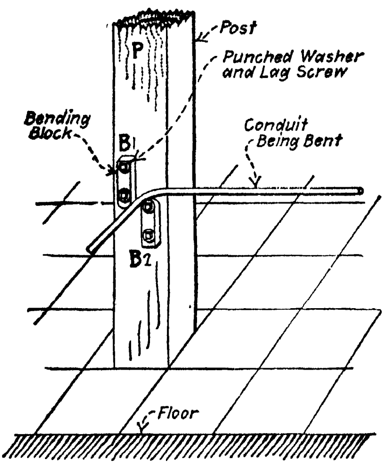



FIG. 189.—Bending blocks mounted on post.

that the conduit will fit into it, will also tend to prevent such accidents. The end of each block should be rounded off as illustrated. By shifting longitudinally the position of the conduit between the blocks and bending it a certain increment in each position, the conduit can thereby be formed into the desired curvature.

NOTE.—CLEATS OR PULLEYS MAY BE USED IN CONSTRUCTING A BENDING RACK instead of the blocks of Fig. 189. In Fig. 190 is shown a bending rack formed from cleats, $C_1$ and $C_2$, nailed to opposite sides of the post, instead of blocks, $B_1$ and $B_2$, nailed to the same side. This arrangement is not as satisfactory as that shown in Fig. 189; since the cleats are further apart as nice a bend cannot be thus obtained. Old wheels or pulleys ($W_1$ and $W_2$, Fig. 191) may also be used. They are very satisfactory and are not as likely to kink the conduit as the blocks or cleats which have more or less sharp edges. An old pulley, $P$, tied to a post, $C$

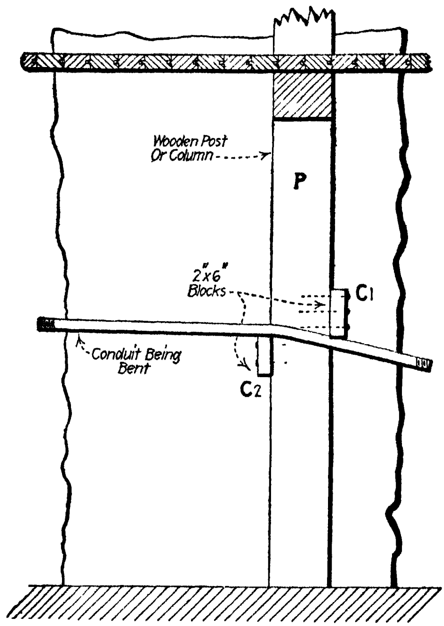



FIG. 190.—Bender made by nailing two blocks on a wooden column.

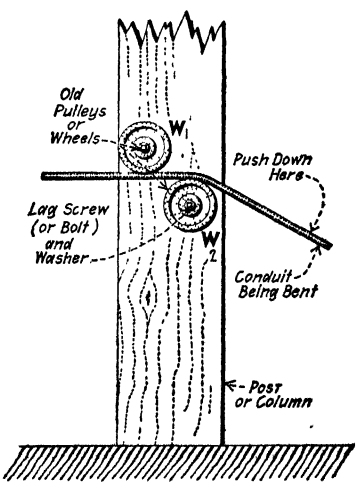



FIG. 191.—Bending rig comprising a couple of old wheels or pulleys bolted to a post.

(Fig. 192) may be used as a conduit bending rack. However, this method is rather crude. Extra leverage is obtained by slipping a large-sized pipe, $S$, over the conduit end. If the conduit end is threaded, a coupling should be screwed on the thread to protect it.

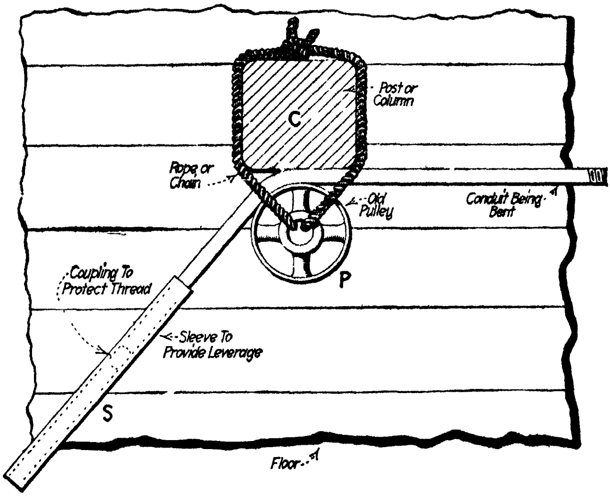



FIG. 192.—Bending small conduit around pulley tied to post.

**134. Bending Blocks Secured To The Top Of The Work-bench** comprise a type of bending rack (Fig. 193) which is very popular for forming ½ and ¾ in. conduits. In some of these racks one form block, $F_1$, has a grooved edge; the other block, $B$, has all of its corners square. The arrangement which has two rounded-corner forms is preferable, in that with it the operator may bend the conduit in either direction. Usually, the blocks, $B$ and $F_1$, are of about the dimensions suggested in the illustration. The effectiveness of the outfit is not impaired even if its dimensions are widely different from those suggested. The blocks are sometimes attached to a plank secured on horizontal members extending from studs in the building. For

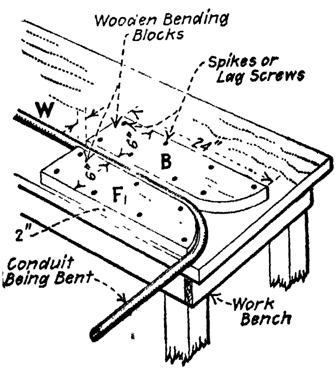



FIG. 193.—Bending blocks mounted on work bench.

best results, the width, $W$, of the slot between the two blocks should be just large enough to admit the conduit. However, ¾- and ½-in. tubes may be satisfactorily handled on the same form.

NOTE.—COMBINATION PIPE VISES AND BENDERS are, in reality, examples of the bending rack as defined in Sec. 124. A typical bender of this type is that (Fig. 194) manufactured by the Austin Company. The conduit to be bent is clamped in the vise, $V$, by tightening the handle, $H$, of the screw and is then bent by the operator around the grooved form as desired.

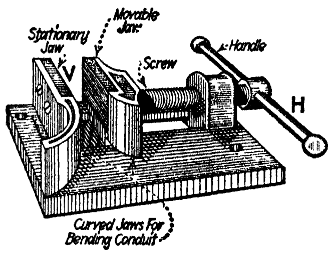



FIG. 194.—Combination pipe vise and bender. Manufactured by the *M. B. Austin Company, Chicago, Ill.*

**135. A Twin-Spool Conduit Bending Rack** (Fig. 195) is often convenient for forming curves in conduits of the smaller diameters. This rack consists of a cast-iron base, $B$, upon which are mounted two grooved metal spools, $S_1$ and $S_2$. Spool $S_1$ is permanently bolted in place, while $S_2$ may be shifted in the slot, to provide for making bends of different radii. A lug, $L$, extends down from the bottom of the base so that it may be gripped in a vise on a work bench.

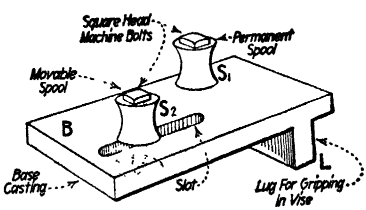



FIG. 195.—A twin-spool bending rig.

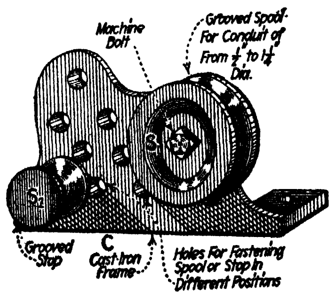



FIG. 196.—The Rex conduit bender. (*M. B. Austin & Company, Chicago, Ill.*)

NOTE.—COMMERCIAL TWIN-SPOOL BENDING RACKS OF A NUMBER OF DIFFERENT DESIGNS ARE MANUFACTURED. One of these of typical design is diagrammed in Fig. 196. All of them comprise about the same elements: *First*, a frame casting, $C$; *second*, a permanently-located,

grooved spool or sheave $S_1$; and, *third*, an adjustable grooved sheave or spool, $S_2$. Racks of this general design are provided with bolt holes whereby they may be attached to the workbench or to some member of the building wherein the conduit is being installed.

**136. A Twin-Spool Rack For Forming Short-Radius Bends In Small Conduits** can be assembled as detailed in Fig. 197. Obviously, this comprises the three essential elements described above: a frame or baseplate, $F$, a stationary spool, $S_1$, and a movable spool, $S_2$. It may be desirable, as in this

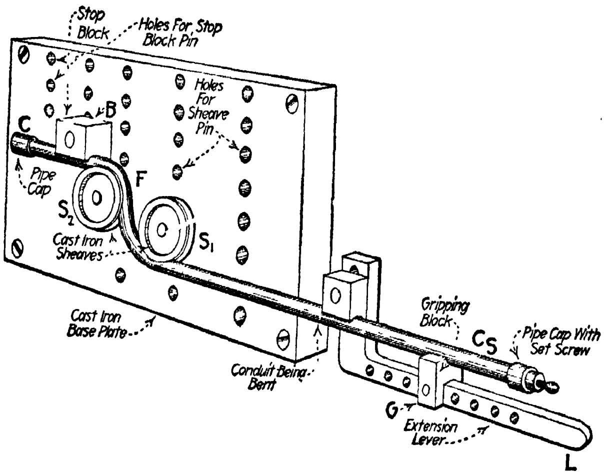



FIG. 197.—Arrangement for making short-turn and complicated bends in small-diameter conduits.

case, to have both $S_1$ and $S_2$ and the stop block, $B$, movable. Where the bends are to be made to a very short radius, it may be necessary to fill the conduits with sand as suggested in Fig. 198 before they are bent.

NOTE.—IN MAKING A BEND WITH THIS DEVICE, (Fig. 197) the sheaves, $S_1$ and $S_2$, and the stop block, $B$, are fastened in their proper locations on the baseplate. If the conduit to be bent is short, the extension lever, $L$, is used in combination with the gripping block, $G$. This increases the length of the lever arm and makes the bending easier. When making short-radius bends, the conduit, $CS$, must, usually, be filled with sand to prevent its collapsing. Two different arrangements are shown in Fig. 198. An important precaution should be observed; if the filled conduit is to be heated prior to bending, the sand must be dry or an explosion may result. Whether or not it is necessary to heat the conduit before the

bend is made, will be determined by its diameter and the radius of the bend.

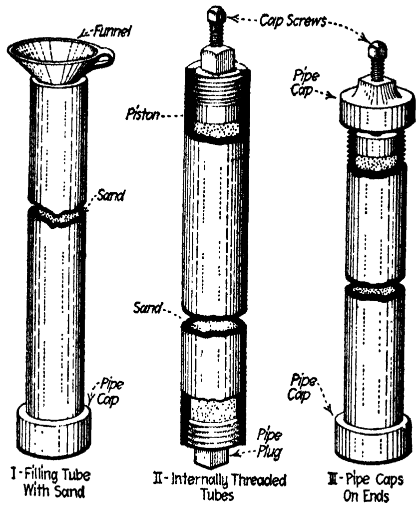



FIG. 198.—Showing how the ends of the conduits to be bent are plugged and how it is filled with sand.

**137. A Shaft-And-Ring Conduit Bender,** sometimes called a bull-ring bender, is detailed in Fig. 199. The method of

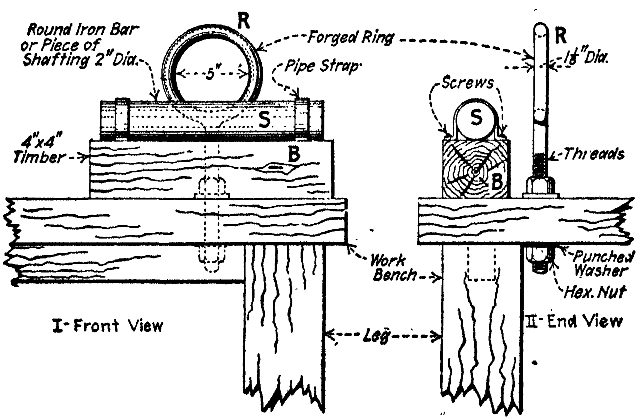



FIG. 199.—Details of construction of the shaft-and-ring bender.

its use is shown in Fig. 200. The shaft (or filled pipe), *S*, is about 12 in. long, while the shank of the eye-bolt is about

14 in. long. The height of the ring, *R*, above the work bench can be adjusted by manipulating the nuts on the shank. The

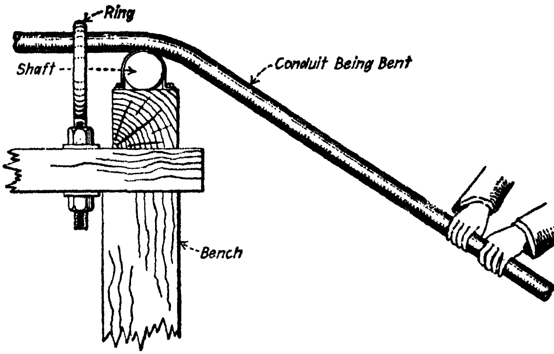



FIG. 200.—Method of using the shaft-and-ring bender.

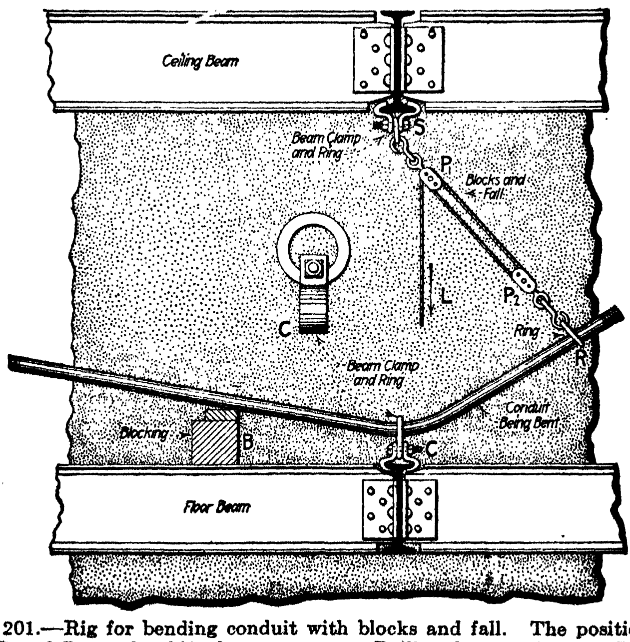



FIG. 201.—Rig for bending conduit with blocks and fall. The positions of *B* and *R* may be shifted as necessary. Pulling down on *L* raises $P_1$.

iron cylinder, *S*, may be fastened to the top of the bench, if a considerable amount of bending of the same size conduit to

the same radius has to be done, but greater flexibility is obtainable if the block, $B$, and the iron cylinder which it carries is not so fastened.

Explanation.—In using the rack, one end of the conduit is inserted through the wrought iron ring and the block is shifted until the iron cylinder rests under the location at which the bend is desired. Then an increment of the curve is formed by bearing down (Fig. 200) on the free end.

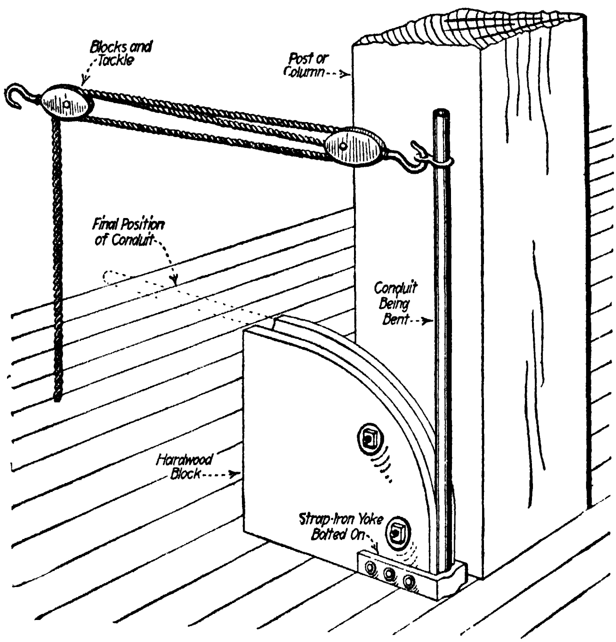



Fig. 202.—Block and tackle used for bending conduit around hardwood form.

**138. A Block And Tackle May Be Used To Supply Force For A Bending Rack,** where relatively large-diameter conduit is to be bent and where difficulties are experienced in obtaining sufficient force to form a conduit by direct pressure manually applied. Such an arrangement is shown in Fig. 201. A ring, $C$, which is fastened to a floor beam, is used to hold the conduit. The hook of one of the blocks, $P_1$, is fastened to a ceiling beam, $S$. Although the illustration shows the method as applied in a building of steel construction, beam clamps can be designed

whereby the scheme can be used in a structure of any kind, A block and tackle (Fig. 202) is often used to pull a conduit

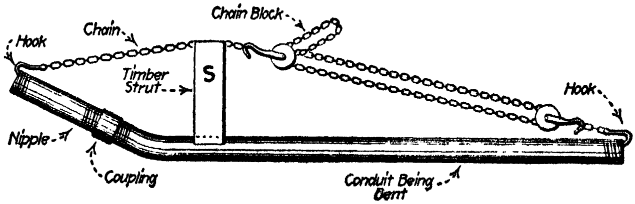



FIG. 203.—Method of bending conduit with chain blocks.

into contour around a hardwood form, $E$. The hook of the fall block is attached to an upright and the conduit pulled

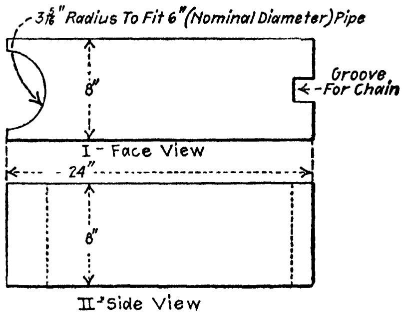



FIG. 204.—Details of timber strut for bending pipe with chain blocks.

into the position shown by the dotted lines. It may be necessary to clap a U-bolt or similar contrivance on the con-

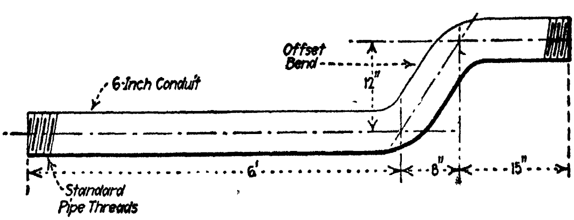



FIG. 205.—Offset bend made with chain blocks.

duit just above the hook, $H$, of the pulley block to prevent the hook from slipping from the end of the conduit.

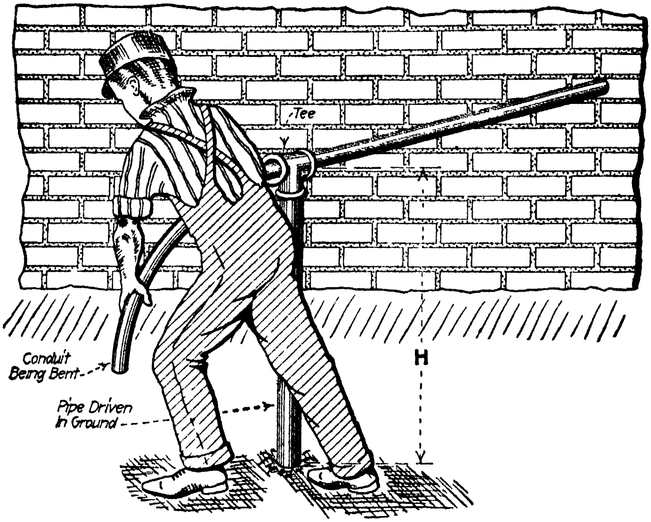



FIG. 206.—Using pipe-tee hickey with its end driven in the ground. The size of the conduit being bent in the above illustration is exaggerated. Ordinarily, conduit larger than ¾ in. can not be bent as above shown

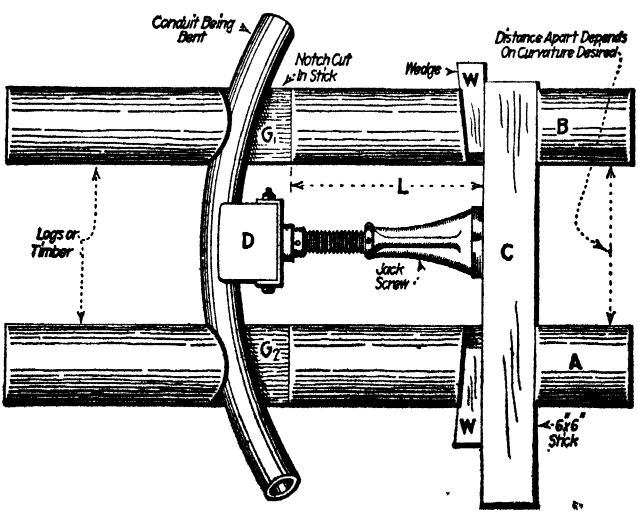



FIG. 207.—Plan view of twin-log bending rig. The distance between $A$ and $B$ is varied with the radius of the desired bend. $G_1$ and $G_2$ are notches cut in the logs. $W$ and $W$ are wooden wedges which hold $C$ in position. The distance $L$ should be about equal to the height of the jack screw.

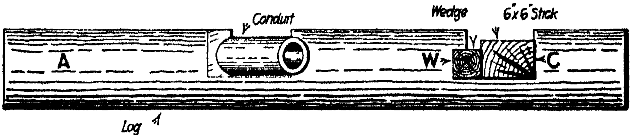



FIG. 208.—Side elevation of twin-log bender of Fig. 207.

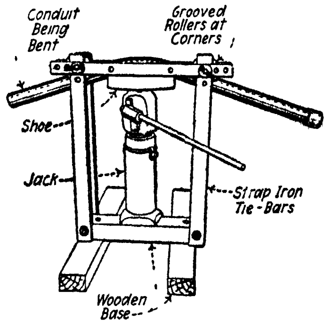



FIG. 209.—Vertical hydraulic-jack bender. This device will bend any conduit from $1\frac{1}{4}$ to 4 in. in diameter. It can be operated by one man and can be used in straightening as well as in bending.

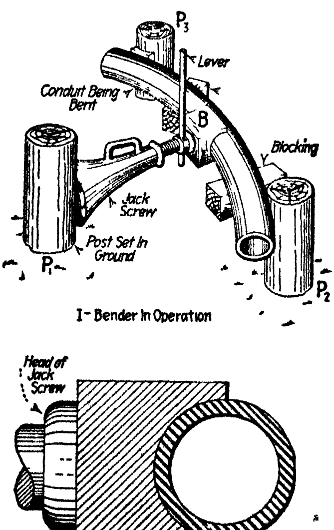



FIG. 210.—An unbraced, three-post bending frame. The distance between posts, $P_1$ and $P_2$ is fixed. $B$ is a wooden block.

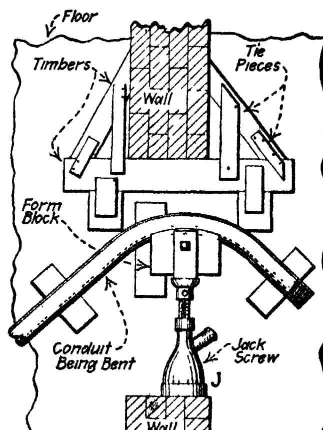



FIG. 211.—Bending conduit in a door or window opening with a jack screw.

NOTE.—A CHAIN BLOCK MAY BE USED TO FORM SHORT-RADIUS BENDS IN CONDUIT (Fig. 203). A block and tackle may be used instead of the chain block. Details of the timber strut, $S$, are shown in Fig. 204. In making these short-radius bends it is usually necessary to heat the conduit to a dull cherry red along the outside of the curve. The inner side of the bend may remain at a "black" heat. Hence, where such a bend is to be made, the conduit should be heated in a forge and be permitted to remain therein while the bends are being formed. It is usually impossible to obtain the required bend at one setting in the forge

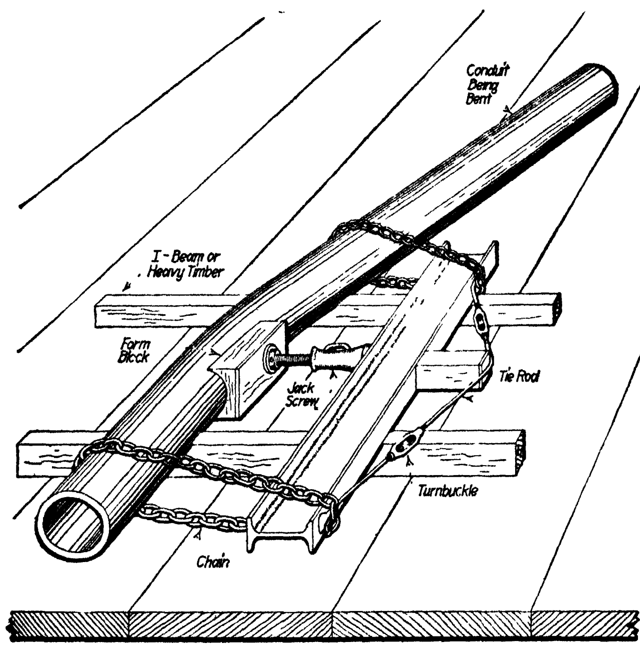



FIG. 212.—Beam-and-jack-screw bending rig for large conduit. A slip link is provided in each chain for rapid adjustment.

and pull of the tackle chain. So after the bend is partially completed, the conduit is shifted in the fire, permitted to become hot and then bent again at a new location. This process is repeated until the desired curvature has been obtained. If the threaded end is near the point where the bend is to be made, a nipple and coupling should be screwed on this end to protect the thread and lengthen the conduit. H. K. Scholefield reports in *Practical Engineer* that two bends similar to those shown in Fig. 205 were made by this method in 4 hr.

**139. An Inverted Pipe-Tee Hickey Bending Rack** (Fig. 206) consists of a malleable-iron pipe tee (of a diameter sufficiently

large to admit the conduit which is to be bent) screwed on the upper end of a piece of pipe which is held to the floor or earth. The height, $H$, of the tee above the surface should be such that the man or men—doing the bending can exert maximum pressure on the extending end of the conduit. Ordinarily this would be about 36 to 40 in.

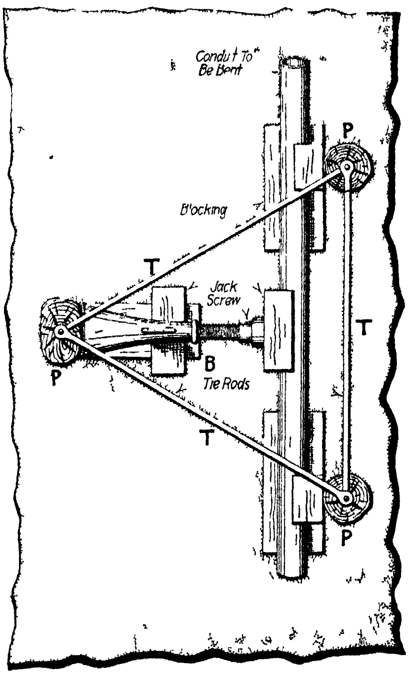



FIG. 213.—Plan view of a braced three-post frame for bending large conduit with a jack screw. Ties, $T$, prevent the posts, $P$, from moving. Blocking is shown at $B$.

**140. Pressure Benders** (Figs. 174, 207 and 208) are essentially bending racks which utilize pressure-producing devices for bending the conduit. With them as with bending racks, it is seldom possible with one setting of the machine to make the bend at the location and with the radius desired. It is usually necessary partially to form the bend with one setting and complete it with new setting. For conduit larger than 2 in. in diameter, it may be desirable to use a hydraulic jack

(Fig. 209) or a pneumatic cylinder (Fig. 174), in preference to a jackscrew, for applying the pressure.

NOTE.—ALL PRESSURE BENDERS ARE CONSTRUCTED IN ESSENTIALLY THE SAME MANNER. They have two supports, *A* and *B* (Fig. 207), for

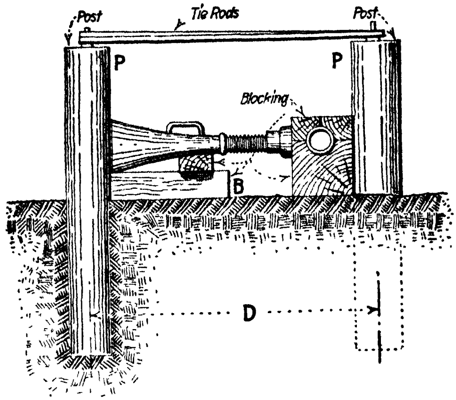



FIG. 214.—Sectional elevation of the bending arrangement of Fig. 213.

holding the conduit on each side of the bend. Between these two supports a pressure-developing device, which has a grooved head (*D*, Fig. 207) is located to provide the pressure necessary to bend the conduit. This pressure device is usually a jackscrew (Figs. 207, 210, 211, 212,

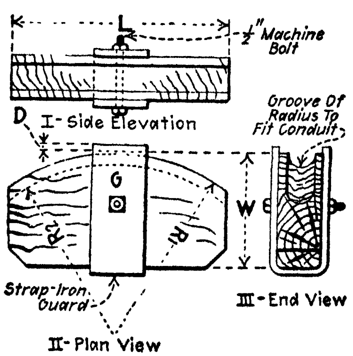



FIG. 215.—Wooden-block head or form for bending large conduit. (Radius $R_2$ is equal to the minimum radius bend desired, and $R_1$ can be obtained therefrom. The distance, *D*, should be ⅛ to ¼ in. Length, *L*, should be equal to $R_1$. Width, *W*, should be at least 6 in.)

213 and 214), although for larger conduit it may be a hydraulic jack (Fig. 209) or a pneumatic cylinder (Fig. 174). Various methods may be used to support the conduit. Some of which are shown in Figs. 207, 208,

210, 211, and 212. Either a wooden block head (Fig. 215) or a steel head (Fig. 174) can be used.

## 141. Roll Benders Will Form Bends In Conduits Of Almost Any Diameter Without Kinking, Buckling, Or Flattening

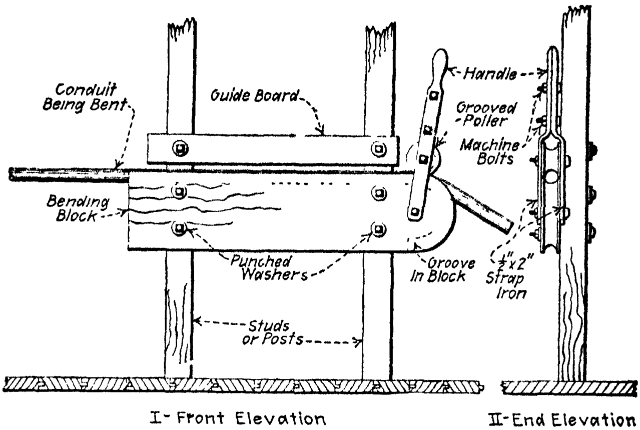



FIG. 216.—Improvised grooved-wheel conduit bender.

them if the bender (Fig. 216) has been properly designed. Experience has shown that when the conduit to be bent is drawn or rolled gradually into a bending form or wheel, the edge of which has been hollowed so that it just fits the tube, the material will, due to the gradual and uniform application of force, be distorted without the imperfections which will be introduced if the tube is bent abruptly. In these roll benders the walls of the conduit are so supported by the bending form that flattening or buckling is thereby prevented.

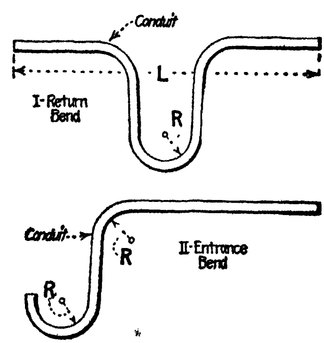



FIG. 217.—Types of bends readily made on the roll bender.

NOTE.—IT IS ALWAYS ADVISABLE TO USE ROLL BENDERS WHERE A LARGE NUMBER OF CONDUITS—regardless of the diameter—are to be bent (Fig. 217) to the same contour. Roll benders insure a uniformity of product otherwise unobtainable. Furthermore, with them bending can be effected with a minimum expenditure of time, hence, at minimum cost.

Roll benders for conduits of the smaller diameters can be improvised, as will be described, from materials which are, usually, obtained readily. On the other hand, it does not ordinarily pay to endeavor to construct a "home-made" roll bender for conduits of the larger diameters. A bender for the large conduits should be purchased from one of the several manufacturers. In ordering a commercial bending machine, the manufacturer should be advised as to the service for which the device is intended, because the design of these machines is, in some cases, different for certain kinds of conduit than for others.

**142. Improvised Roll Benders** may be made in various ways. They may have either a wooden bending form as (Figs. 216

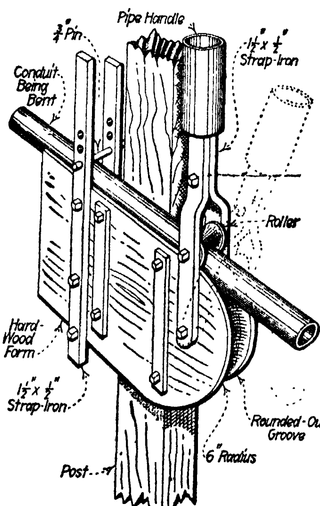



Fig. 218.—A substantial improvised lever-and-roller bender. (W. E. Chandler in *Power*, Jan. 12, 1915.)

and 218) or a roller or sheave bending form (Figs. 175, 219, 220, 221 and 222). The handle should in each case be long so as to insure ample leverage. For best results the grooves in the sheave should fit the conduit to be bent with as little clearance as possible. The pivots and bending wheels should be of substantial design as they must withstand considerable stress. The roll bender may be designed to operate in a vertical plane (Figs. 175, 216, 218, and 221) or in a horizontal plane (Figs. 219, 220 and 222) for a work bench. With a roll bender working in the vertical plane, a little more power

may be obtained due to the use of the weight of the body. In bending, the conduit is inserted between the bending rolls which then lie in the positions indicated by the dotted line in

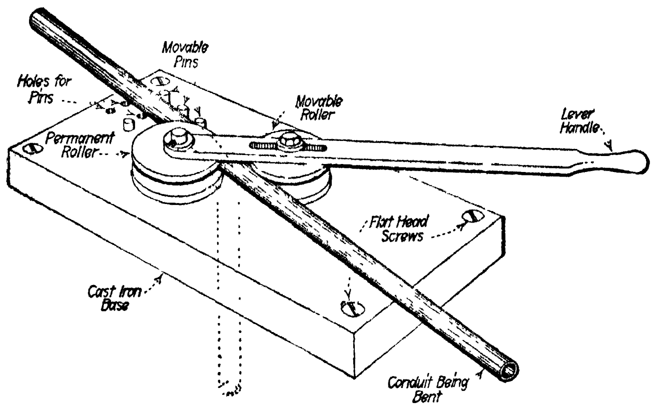



**FIG. 219.—All-metal, roller bender to be permanently mounted on bench top.**

Fig. 175. Then to bend the conduit, the lever is pulled toward the operator, which forces the conduit into a bend of the radius of the stationary form or roll.

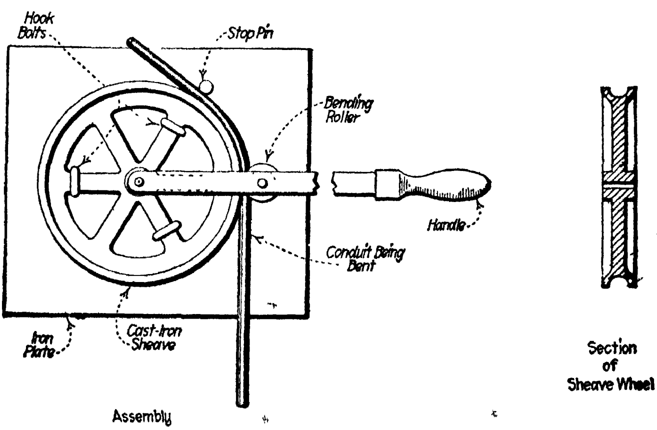



**FIG. 220.—Conduit bender made from a sheave wheel.**

**NOTE.—THE ROLL BENDERS WHICH HAVE A MOVABLE ROLLER AND STOP PINS (Fig. 219) have the advantage that bends of different radii may be made. To accomplish this the bend must not be made at one setting, but instead the conduit should be bent by increments and the position changed after each increment.**

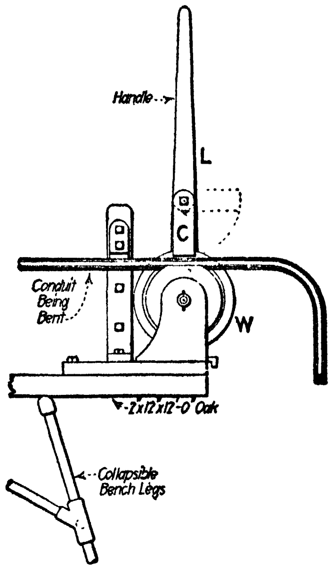



FIG. 221.—The Hercules bender invented by *G. E. Phillips of Sarnia, Ontario.* In using this bender, the conduit is first held between the flat place in wheel, *W*, and the clamping plate, *C*. Pulling lever, *L*, then draws the conduit around the grooved form of wheel, *W*.

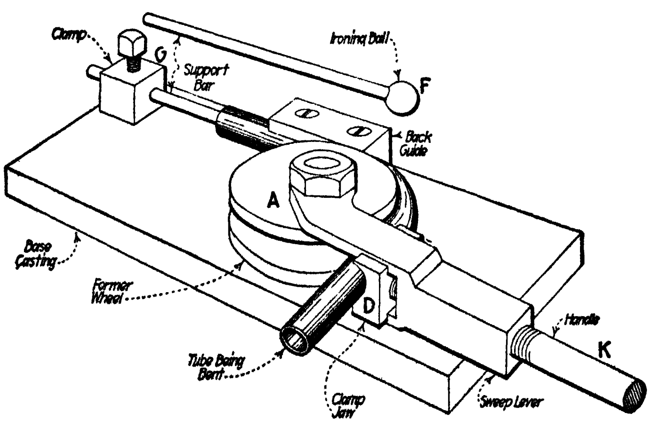



**FIG. 222.—Jig for bending thin tubes. This device is similar in operation to that shown in Fig. 221. Its feature is the ironing ball which is used to prevent buckling when making short radius bends. (*F. C. Mason. American Machinist*, Dec. 9, 1915, p. 1040.)**

NOTE.—ONE TYPE OF COMMERCIAL ROLL BENDER FOR CONDUIT (Fig. 223) is similar in construction and operation to the improvised roll benders shown. Its feature is the clamp for holding the conduit. It has the disadvantage that bends greater than 90 deg. cannot be formed in one setting.

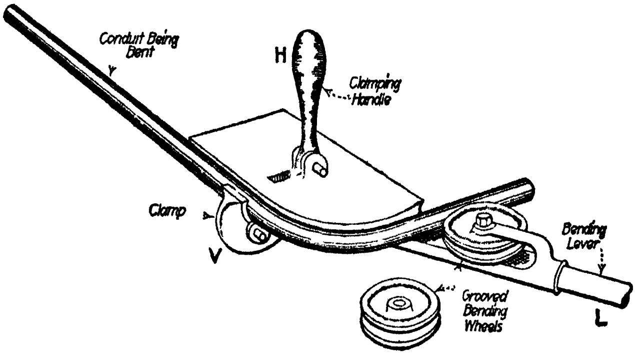



FIG. 223.—A typical commercial roll bender for conduit work. (*Thomas & Betts, New York City*)

## 143. The Bending Force In A Roll Bender For Large Conduits May Be Applied Through Chain Blocks (Fig. 224).—

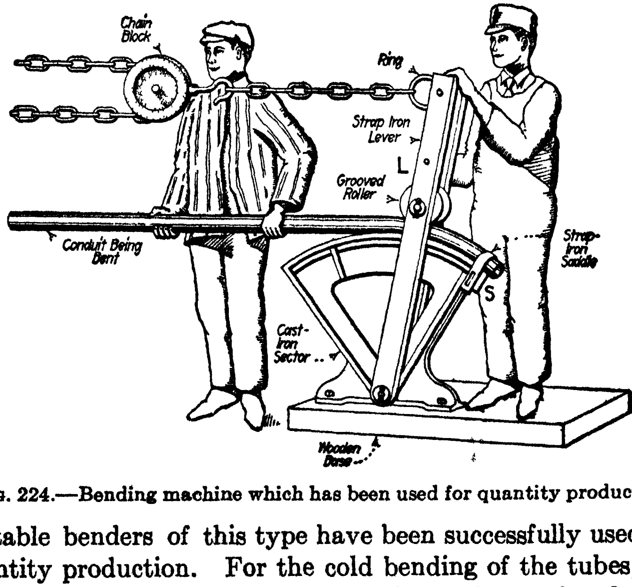



FIG. 224.—Bending machine which has been used for quantity production.

Portable benders of this type have been successfully used for quantity production. For the cold bending of the tubes, the end of the straight conduit to be bent is first inserted under the

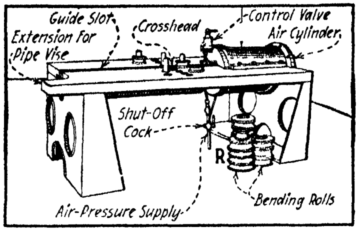



Fig. 225.—Pneumatic conduit bender designed, built and used in the Dectaur Shops of the Wabash Railroad. Similar benders are employed by the Southern Pacific Railroad and the Westinghouse Electric & Manufacturing Co. for bending conduit for car wiring. It requires only about ½ min.—the time consumed by the piston in moving a stroke—to form a bend with the machine. Rolls, *R*, of various external diameters and having grooves of different sizes are provided for forming bends of different radii in tubes of different diameters. Air pressure is 100 lb. per sq. in. See Figs. 226 and 227 for details.

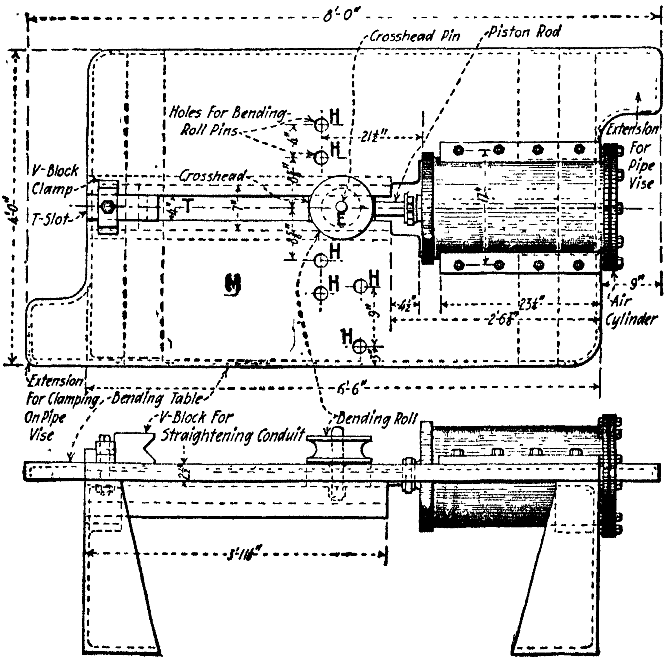



Fig. 226.—Assembly of the "Wabash" pneumatic bender. In bending, the conduit, it is so placed on table, *M*, that it lies across the T-slot, *T*, and in the grooves of two stationary bending rolls which are placed on bending-roll pins in *H* and *H*. Then when air is admitted to the cylinder, the piston forces another bending roll (which has been placed on crosshead pin *E*) longitudinally along the table, thus bending the conduit. By using bending rolls of different diameters and by arranging them in as required over the holes, *H*, bends of the contour desired may be obtained.

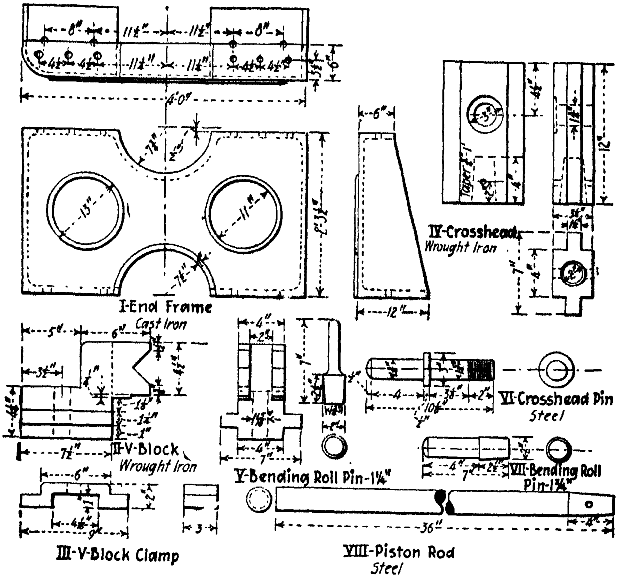



FIG. 227.—Details of the "Wabash" pneumatic conduit bender.

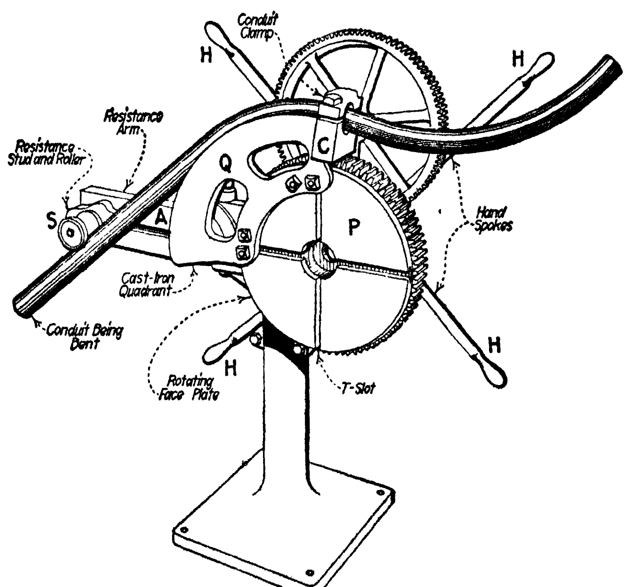



FIG. 228.—Pedrick bending machine, forming turn in $1\frac{1}{2}$-in. conduit.

strap iron saddle, *S*. Then as force is gradually exerted on the lever, *L*, with the chain blocks, the grooved roller is pulled along over the sector, pushing the tubing into the groove.

**144. Pneumatic Conduit Benders** (Figs. 174, 225, 226 and 227), which operate by *compressed air*, are very economical

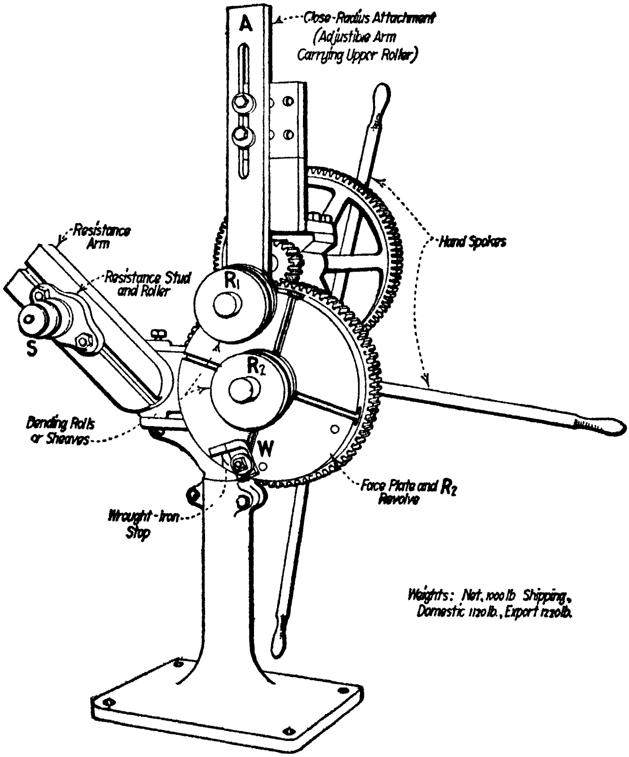



FIG. 229.—Pedrick bending machine set up for making short radii bends. *W* is a stop to hold the conduit end in place.

and effective where wiring is being done on cars or on similar equipment in shops where compressed air is available.

**145. The Pedrick Bending Machines** (Figs 228 to 233) are typical of certain lines of machine benders which have been developed in this country. In these machines the conduit to be bent is secured in the clamp, *C* (Fig. 228) at the end of the cast-iron quadrant, *Q*. Then the face-plate, *P*, is rotated by

pulling on the hand spokes, *H*. Reduction gears are inserted so that the force exerted is multiplied enormously when

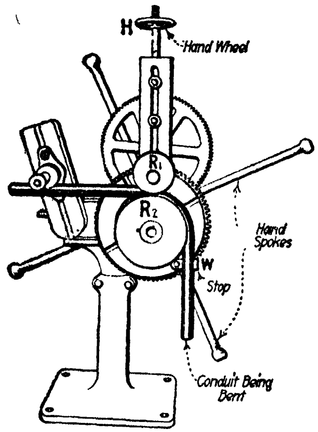



FIG. 230.—Forming a right-angle, 5-in. radius bend in 1½-in. conduit. (Note the hand wheel, *H*, on the top of the close-radius attachment which is used for imposing pressure on the roll $R_1$.)

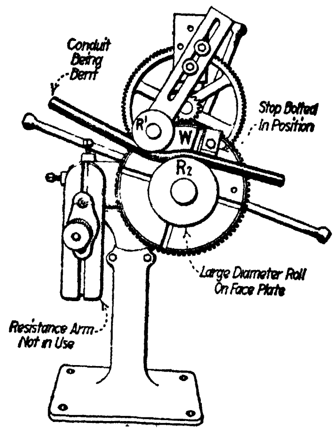



FIG. 231.—Bending an offset with the roll bender. Other satisfactory pipe bending machines are made by the "Watson-Stillman" and the "Henderson" companies.

imposed on the conduit. As the plate is turned, the conduit is drawn into the groove and assumes the contour of the

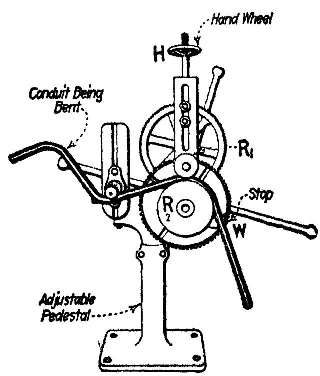



FIG. 232.—Forming a double-right-angle bend on the roll bender. (The radius for all of these bends is 5 inches.)

quadrant. The resistance stud and roller, *S*, which are mounted on arm, *A*, restrain the free end of the conduit. It

is desirable to locate the resistance stud, $S$, as far from the quadrant as is feasible because excessive stresses are thereby minimized.

NOTE.—BENDS OF DIFFERENT RADII CAN BE MADE BY USING DIFFERENT QUADRANTS. The standard equipment consists of the following quadrants: 1-in. conduit, 6-in. radius; 1¼-in. conduit, 9-in.

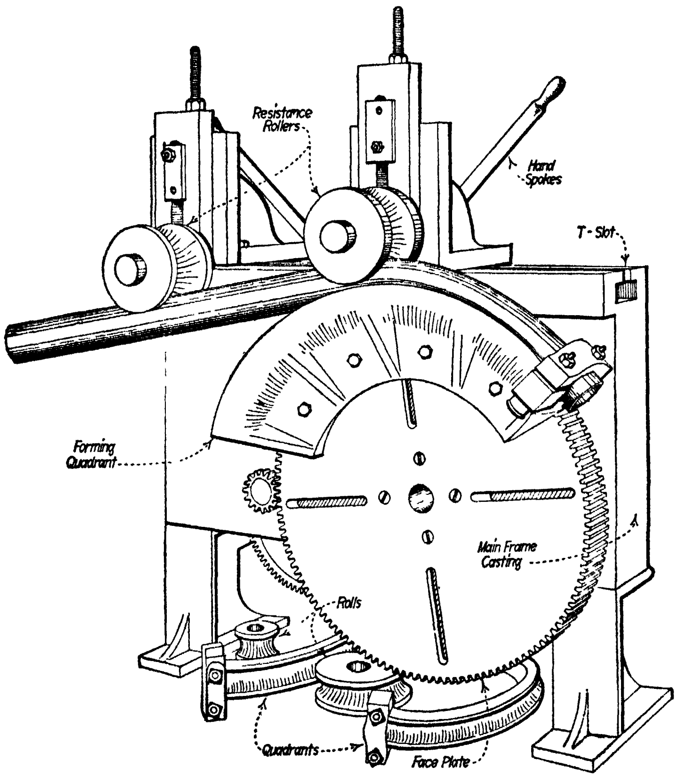



FIG. 233.—Bender—either hand or power driven—for large-diameter conduits up to 4½ in. diameter.

radius; 1½-in. conduit, 12-in. radius; 2-in. conduit, 14-in. radius. For smaller radii bends the bender must be modified, as illustrated in Fig. 229, by the addition of an adjustable arm, $A$, which carries on its lower end a roll, $R_1$. The bending roll, $R_2$, is substituted for the quadrant. Figures 230, 231, and 232 illustrate how the different bending operations are performed with the device. For bending conduit between 2 in. and 4½ in. in diameter the machine shown in Fig. 233 should be used. The elements of this machine are the same as those for the bender of Fig. 228 except that they are heavier.

**146. In Forming A Right-Angle Bend, By Hand, With A Hickey** the first step is to ascertain, by measurement with a 6-ft. folding rule at the place where the conduit is to be installed, just where the bend should be located in the conduit.

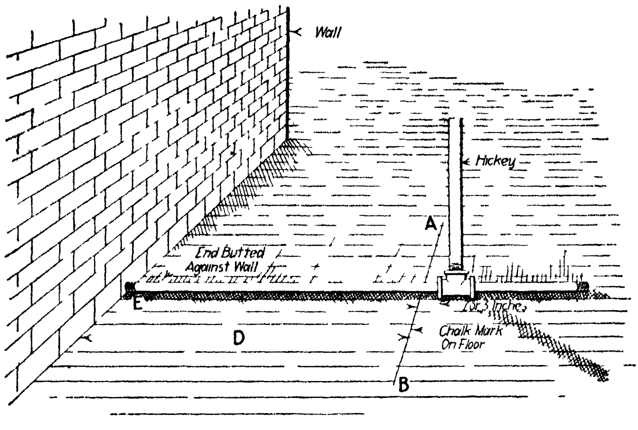



FIG. 234.—First operation in forming a bend with a hickey. Distance from outside of bend to wall has been laid out on floor.

Then the distance (*D*, Fig. 234) from the end of the Conduit to the outside of the bend which is to be formed should be marked on the floor by drawing a line (*AB*, Fig. 234) with a piece of chalk. (It is useless to endeavor to make a bend accurately in a piece of conduit by marking the bending point on the conduit itself, Fig. 235). Now, butt the end of the conduit (*E*, Fig. 234), in which the bend is *not* to be made, against a wall or similar vertical member of the building. Place the hickey over the other end of the tube at a location about 2 or 3 in. outside of the mark on the floor, as indicated in the illustration. Next, stand on the conduit just inside of the location mark on the floor and pull over the hickey, drawing the conduit end through an angle of about 20 deg. (Fig. 236). And, still standing on the conduit, move the head of the

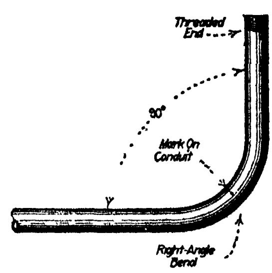



FIG. 235.—Showing chalk line or center-punch mark on conduit.

bender along the conduit toward the wall about 1 in. and bend the conduit a little further (Fig. 237).

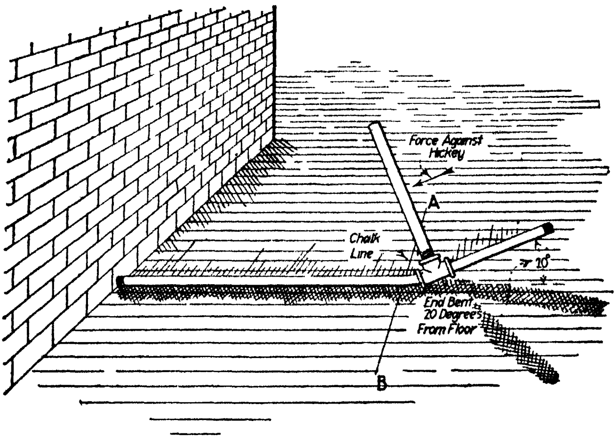



FIG 236 —Second operation The bend started.

Repeat this process until the turn has assumed the contour desired and until the outside face of the bend is in vertical

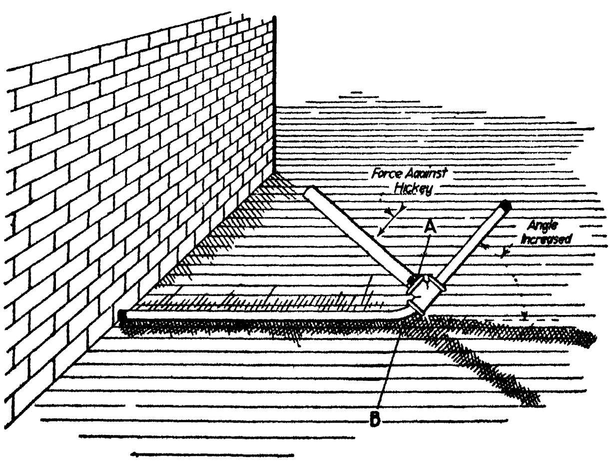



FIG. 237.—Bend partially completed.

alignment with the chalk mark made on the floor (Fig. 238 at *MN*). If the bend is not made in small increments, kinks

(Fig. 420-*II*) will be introduced or the conduit may even be cracked. It may be necessary in finishing the bend, so that it will occupy just the right position in the tube, to invert the hickey and use its handle as a lever on the tube (Fig. 238). The process is essentially a "cut-and-try" one. A little practice is all that is necessary to render any one proficient. If the bend first formed is of too long a radius, the difficulty may be corrected by following the procedure outlined under Sec. 150.

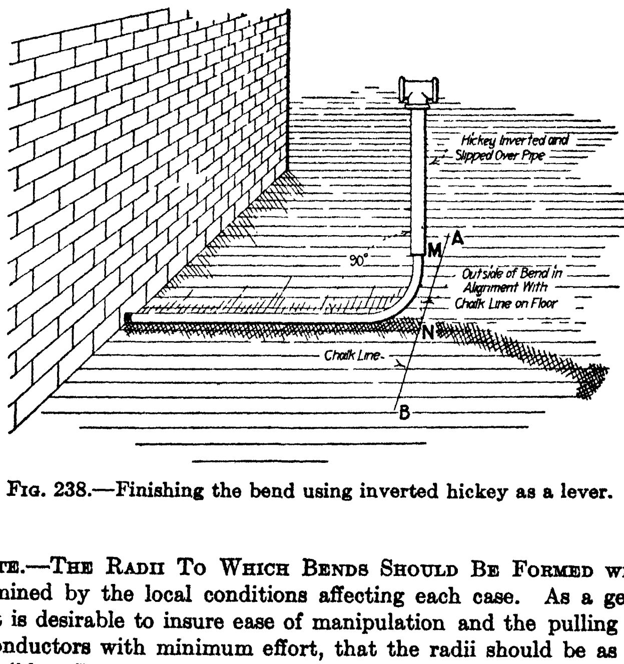



FIG. 238.—Finishing the bend using inverted hickey as a lever.

NOTE.—THE RADII TO WHICH BENDS SHOULD BE FORMED will be determined by the local conditions affecting each case. As a general rule it is desirable to insure ease of manipulation and the pulling in of the conductors with minimum effort, that the radii should be as large as possible. In the NATIONAL ELECTRICAL CODE it is specified that the minimum radius of the inside of any bend should be 3½ in. This value should certainly be taken as a minimum where the bend is in a long conduit run. But where the distance between outlet boxes is short and where there are not more than two bends in the run, the shortest radius bend which it is possible to make will ordinarily be accepted by wiring inspectors.

**147. A Right-Angle Bend May Be Made With Two Hickeys (Figs. 239 and 240).**—This method may be desirable where a

number of lengths of conduit must have formed in them turns of uniform contour. While with obvious variations the general procedure indicated may be followed for bends of almost any degree, the directions given in the note relate specifically to 90-deg. or right-angle elbows in ½-in. conduit.

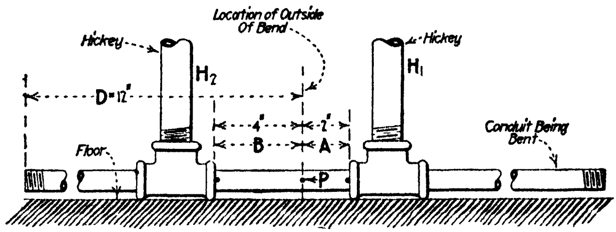



Fig. 239.—First position in forming a bend with two hickeys. (Dimensions shown are those for ½-in. conduit.)

Where a roll bender is available it should be used in preference to the two hickeys.

Note.—The Procedure Is As Follows: First, lay off the required dimensions ($D$, $B$, and $A$, Fig. 239) and mark them on the conduit either with chalk or a center punch. Then, placing the hickeys, $H_1$

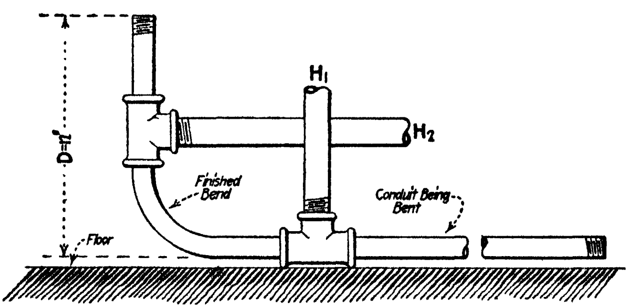



Fig. 240.—Second position when forming a bend with two hickeys.

and $H_2$, on the marks indicated and holding $H_1$ vertically, force $H_2$ around until it lies at right angles to $H_1$ (Fig. 240). . The bend will thereby be formed and it will be in the location required.

**148. Table Indicating Locations Of Hickeys When Forming A Right-Angle Bend By The Two-Hickey Method.**—The values of Table 149 may be employed instead of those given

below in which case the bend formed will have a larger radius. (The reference letters are those in Fig. 239.)

| Size conduit | *A* Distance from location line to face of hickey $H_1$ | *B* Distance from location line to face of hickey $H_2$ |
|---|---|---|
| ½ in. | 2 in. | 4 in. |
| ¾ in. | 3 in. | 5 in. |
| 1 in. | 4 in. | 6 in. |

**149. Table Of Values Useful For Locating Right-Angle Bends** (Fig. 241) in conduit. The method of obtaining these values is given in the note and their use is illustrated in the

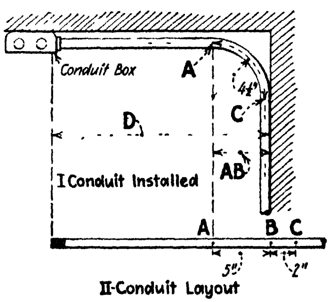



FIG. 241.—Showing the method in which values given in Table IV are used. The dimensions given pertain only to ½-in. conduit. Note that the distance *AC* in *I* is equal to *AC* in *II*.

following example. The values may be used when locating the hickeys (Fig. 239) when two are used, in making a right-angle bend. When a bend is to be made with a roll bender, only the length *AB*, need be used.

| Size of conduit | Outside diameter of conduit, in. | Standard radius of center line of bend, in. | *AC* Total length of bend, in. | *AB* − in. | *BC* + in. |
|---|---|---|---|---|---|
| ½ | ⅞ | 4½ | 7 | 5 | 2 |
| ¾ | 1 1/16 | 5⅜ | 8½ | 6 | 2½ |
| 1 | 1 5/16 | 5¾ | 9 | 6½ | 2½ |
| 1¼ | 1⅝ | 7¼ | 11¼ | 8 | 3¼ |
| 1½ | 1⅞ | 8½ | 13¼ | 9½ | 3¾ |
| 2 | 2⅜ | 9½ | 15 | 10½ | 4½ |
| 2½ | 2⅞ | 10½ | 16½ | 12 | 4½ |
| 3 | 3½ | 13 | 20½ | 14¾ | 5¾ |
| 3½ | 4 | 15 | 23½ | 17 | 6½ |
| 4 | 4½ | 16 | 25 | 18¼ | 6¾ |

EXAMPLE.—Assume that a ½-in. conduit is to run from a ceiling outlet box (Fig. 241-*I*) across the ceiling to the wall and down along the wall. To locate the bend properly proceed as follows: On the conduit length, lay off the distance, *D*, thus obtaining the point, *B*. Under the column marked "*AB*," of the table and opposite ½-in. conduit, find 5 in.; and under column "*BC*," find 2 in. From the point, *B*, lay off *A*, 5 in. to the left and *C*, 2 in. to the right (Fig. 241). Then if the bend is started at *A*, and finished at *C*, it will be properly located.

NOTE.—THE VALUES GIVEN IN THE TABLE ARE OBTAINED IN THE FOLLOWING MANNER: The length of the arc *AC* must be equal to ¼ of the circumference of a circle of the standard radius of bend, assuming a perfect bend which is practically obtained. For ½-in. conduit, taking a standard radius bend of 4½ in., *AC* must equal: $\frac{1}{4} \times \pi \times 2R = \frac{1}{4} \times 3.14 \times 2 \times 4.5 =$ approximately 7 in. as given in the table. Now if the bend is to be located so that one side of the conduit is to be along the wall (Fig. 241-*I*), the bend must start at a distance *AB*, from the wall. The distance *AB*, will be (*radius of the center line of the bend*) + (*the radius of the conduit*) $= 4.5 + 0.5 = 5$ *in.* approximately. Hence, the bend must start at a point 5 in. to the left of *B*, and must continue for 7 in. ending at *C* a point 2 in. to the right of *B*. If it is desired to locate bends of different radii from those given in the table, the method just described may be used for obtaining the lengths *AB* and *BC*.

**150. To Make A Short-Radius Bend In Conduit** for a location such as that indicated in Fig. 242, the method to be described can be used. Where turns of the usual radius are

made, the conduits do not lie close to the surfaces. They then present an undesirable appearance (Fig. 243). But

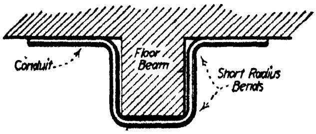



FIG. 242.—Conduit with short-radius bends installed around beam.

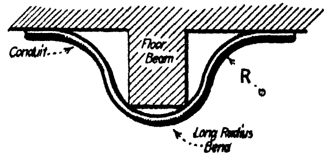



FIG. 243.—Conduit with long-radius bends installed around beam.

with this method, bends of the approximate form shown in Fig. 242 can be so made that the inner face of the conduit

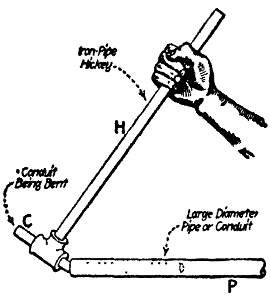



FIG. 244.—Method of forming short-radius bends.

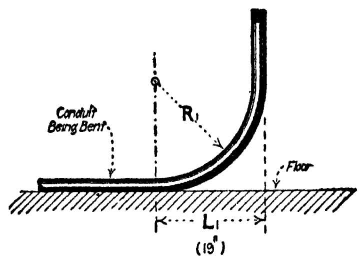



FIG. 245.—Showing the elbow which is to be shortened.

will lie not more than 1¼ in. from the faces of the beam. A sleeve, *P*, of a larger diameter than the conduit, *C*, being

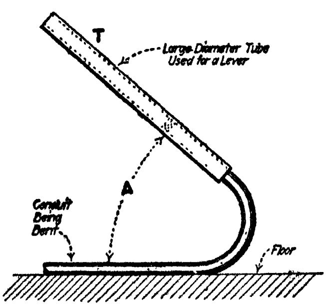



FIG. 246.—Method of shortening the bend—first operation.

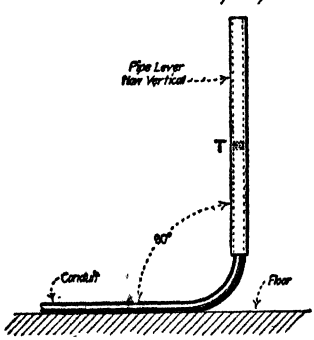



FIG. 247.—Method of shortening the bend—second operation.

bent is slipped over the end of the conduit (Fig. 244) and then the short-radius turn can be formed.

NOTE.—TO SHORTEN A BEND (Fig. 245) which has already been formed, a tube, *T*, (Fig. 246), of such diameter that it will slip over the conduit is used as a lever and the end of the conduit (the operator standing on it to hold it to the floor) is bent back so that the angle *A* is somewhat less than 90 deg. Then the lever tube (*T*, Fig. 247) is slipped down further on the conduit and the conduit then bent back to a vertical position. Thus the radius of the bend may be decreased from that of $R_1$ of Fig. 245 to $R_2$ of Fig. 248.

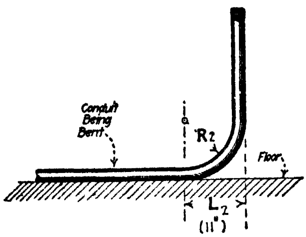



FIG. 248.—Completed bend.

**151. In A Multiple-Conduit Run The Conduits Should Lie Parallel,** both in the straight portions of the runs and at the turns. Fig. 249 shows the appearance of a turn in a

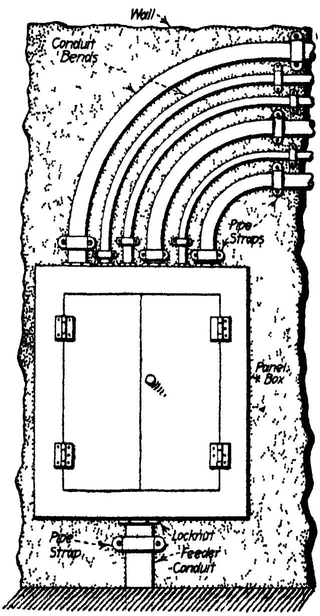



FIG. 249.—Showing a right-angle turn made in a conduit run with bent conduits.

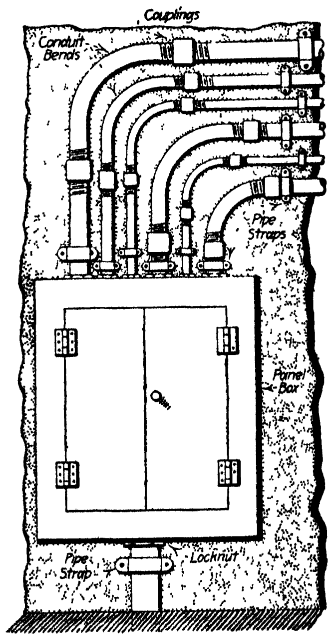



FIG. 250.—Showing a right-angle turn made in a conduit run with conduit elbows.

multiple run where the conduits do lie parallel to one another, while Fig. 250 indicates how the same run would look if standard elbows or bends, formed without any reference to

symmetry were used. To insure a neat appearing turn outlined in Fig. 249, it is necessary to lay out the contour of each bend with a chalk line on the floor and then form the

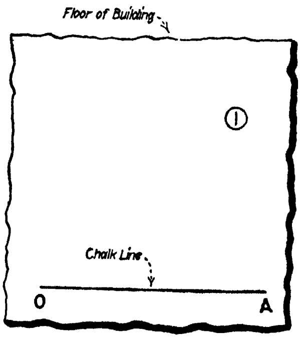



FIG. 251.—First operation in laying out a conduit bend.

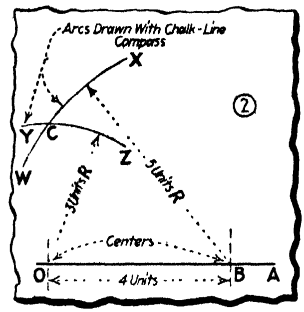



FIG. 252.—Second operation in laying out a right-angle conduit bend.

turn to it. How this may be done is described in the following note.

NOTE.—IN LAYING OUT RIGHT-ANGLE BENDS for conduit runs the procedure is as follows: First (Fig. 251), draw a chalk line, *OA*, of any length (preferably 4 or 5 ft. long) on the floor. Second, lay off the dis-

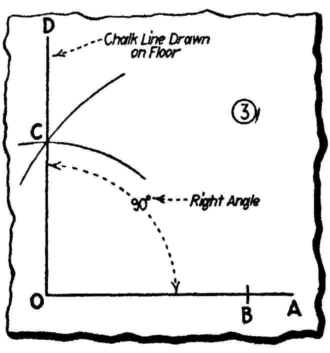



FIG. 253.—Third operation in laying out a right-angle conduit bend.

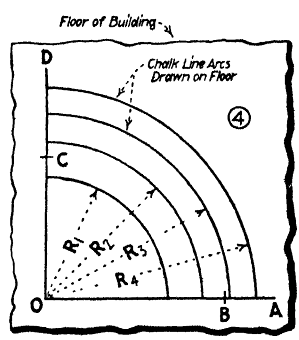



FIG. 254.—Fourth operation in laying out a right-angle conduit bend.

tance *OB* (Fig. 252) 4 units long. The units may be any dimension. That is, 1 ft. may be taken as a unit or 1 in. or 6 in. However, 1 ft. ordinarily affords a convenient unit. With a piece of chalk tied on the end of a length of string for a compass, and with *O* as a center and a radius of 3 units, describe the arc *YZ*. With *B* as a center and a radius

of 5 units describe the arc *WX*. Now, draw a line, *OD* (Fig. 253), through the intersection *C*, of the two arcs. The line *OD* will then be at right angles to *OA*. Now *OD* and *OA* may be prolonged to any required length. Then, with *O* as a center, the different arcs, to which the conduits of the multiple run are to be formed, are drawn on the floor (Fig.

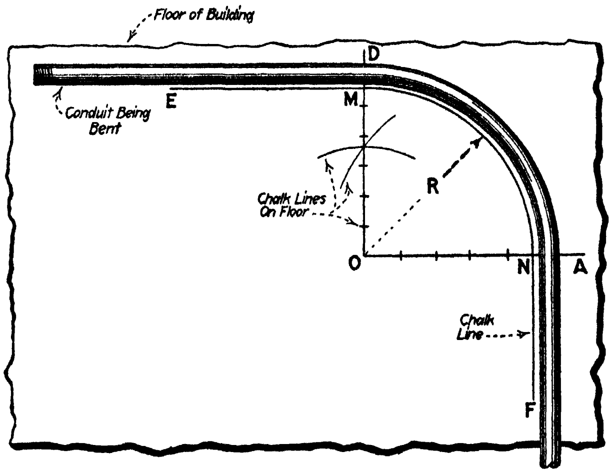



FIG. 255.—Showing how the bend should be formed to a chalk line.

254) with the chalk-line compass. As suggested in Fig. 255, when a bend is being formed it must, from time to time, be laid on the floor at the side of the chalk line drawn for it, to insure the proper contour. It is usually desirable to draw the chalk lines *EM* and *NF* as part of the layout to assist the operator in the correct formation of the elbows.

**152. In Making Short-Radius End Bends** such as may be required where an elbow enters an outlet box (Fig. 256)

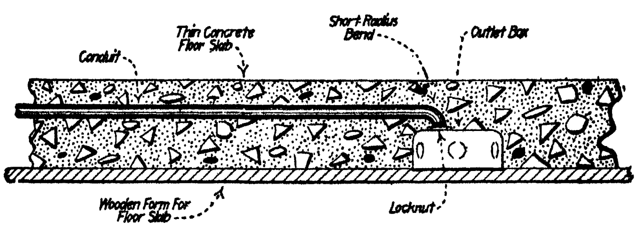



FIG. 256.—Showing how a short-radius bend is necessary in a thin floor slab when the conduit feeds into the outlet box from the top.

special methods must be adopted. Such bends differ from ordinary short-radius bends in that they must be threaded. These are frequently required in thin concrete floor slabs

when it is desirable that the conduit enter the bottom of the box (Fig. 256). The feature that necessitates unusual handling is that the bent end of the conduit must be threaded The first step is shown completed in Fig. 257. The bend of the short radius, *R*, has been formed, the coupling, *C*, having been turned on the threaded end of the conduit to prevent the mutilation of the threads during the bending process. The bend at *R* should ordinarily be of the shortest radius which it is possible to make. Next, the die in the pipe stock is reversed in its socket (Fig. 258) and the end of the conduit is then threaded as far as it is possible to turn the die on the

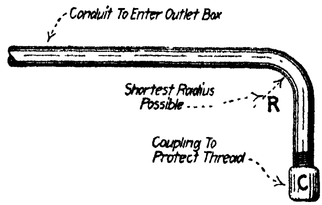


FIG. 257.—Completion of first operation in forming short-radius bend for outlet box.

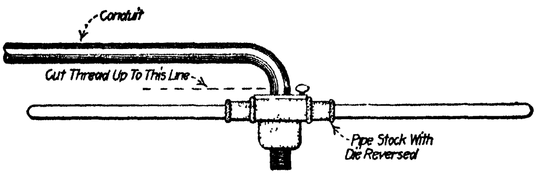


FIG. 258.—Cutting thread on conduit end with die reversed.

conduit (Fig. 259). Now the surplus length (*L*, Fig. 260) is cut from the end, so that the threaded portion, *P*, which remains, is merely long enough to accommodate the locknut,

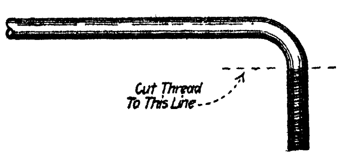


FIG. 259.—Conduit end threaded up to bend.

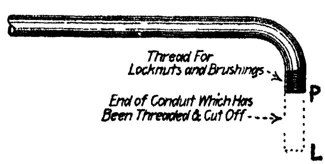


FIG. 260.—Conduit end cut off and ready for insertion in outlet box.

the bottom of the outlet box and the bushing (Fig. 256). Elbows which measure only 2¾ in. from the end of the pipe to the inside of the bend have been made by following this process.

**153. When Bending Conduit Elbows For Ceiling Outlets** it is sometimes desirable to arrange a form or templet like that

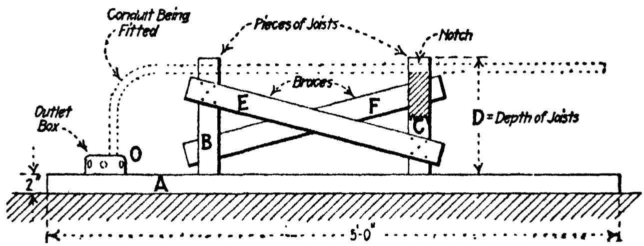



FIG. 261.—Templet for fitting outlet-box bends.

detailed in Fig. 261. The pieces *B* and *C* are sections cut from joists of the same depth, *D*, as those used in the building in which the installation is being made. *E* and *F* are braces. *A* is a plank about 5 ft. long and 2 in. thick. An outlet box, *O*, of the type being used is mounted on the plank as shown. Then, after each bend is formed it can be tried in this templet which lies on the floor, to insure that the bend will fit without having to take it to the location to where it is to be installed. In using this scheme, the short legs of the bends can first be made somewhat longer than is actually necessary and then threaded and cut off to fit. This procedure may be more economical than endeavoring to bend the short leg to the correct length. The plan is particularly desirable where the conduit lengths being used do not have perfect threads on them and therefore must, in any event, be rethreaded.

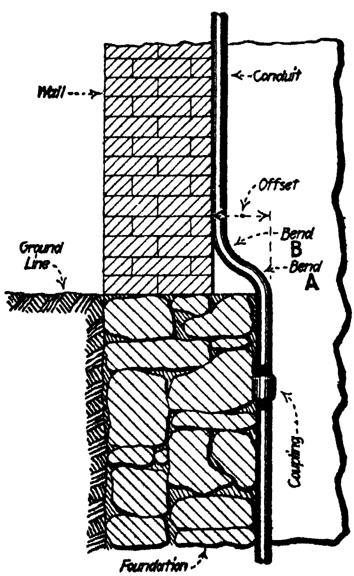



FIG. 262.—An offset bend in a conduit run. The "offset" is, usually, taken as the distance between the center lines of the two runs, instead of from "out" to "out," as shown above.

**154. In Bending Offsets** (Fig. 262) the following method is the one most frequently adopted. As is evident from the illustration, an offset bend involved the forming of two curves in the conduit, the extending ends of which must lie in directions parallel to one another. The first bend ($A_1$, Fig. 263) is

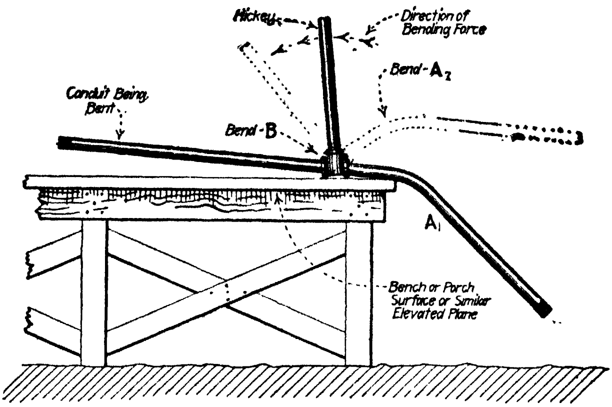



FIG. 263.—Method of making an offset bend with a hickey.

made with a hickey in the manner described in Sec. 461 This bend is not ordinarily one of 90 deg. Then to make the second bend, $B$, the conduit is laid on a plane raised above the surrounding surface. By placing the hickey over the conduit as suggested in Fig. 263 and forcing it in the direction indicated

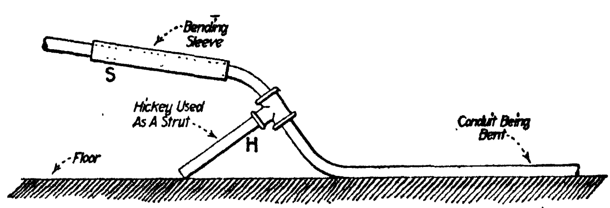



FIG. 264.—Second operation in forming an offset with a bending sleeve and a hickey.

by the arrows, the second bend, $B$, can be formed, the first bend then taking the position $A_2$.

NOTE.—ANOTHER METHOD OF FORMING AN OFFSET (Fig. 264) involves the use of a hickey, $H$, and a bending sleeve, $S$. In forming the first bend, the tools are arranged as shown in Fig. 265. To make

the second bend the short-handled hickey is braced against the floor (Fig. 264) and the wireman forces down on the bending sleeve, which has been inserted over the conduit, until the two ends of the conduit lie in parallel directions with their center lines the requisite distance from one another.

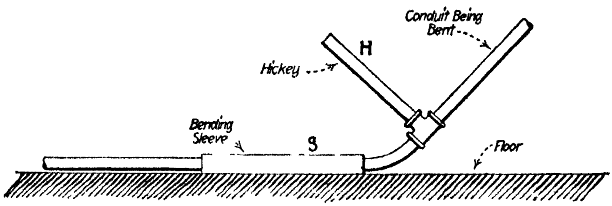



FIG. 265.—First operation in forming an offset with a bending sleeve and a hickey.

**155. The Length Of Conduit Required For The Offset Length In An Offset Bend** can be computed by multiplying the offset distance (*O*, Fig. 266) by the secant of the offset angle, *A*. These secant values for different angles may be obtained from most tables of trigonometric functions (see the author's "American Electricians' Handbook").

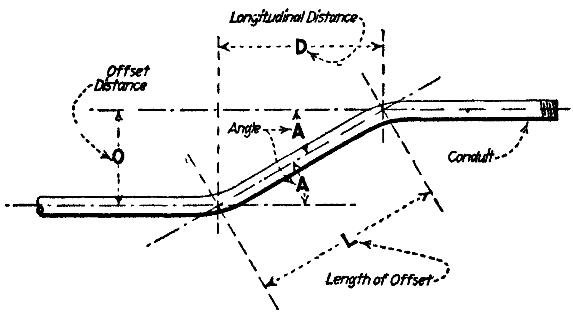



FIG. 266.—Illustrating length of conduit required for an offset.

The quickest way, usually, is to lay off on the floor full size the angle, *A*, and the offset distance *O*, and then measure the length of the offset length, *L*.

**156. In Forming A Number Of Duplicate Bends With A Roll Bender** the scheme suggested in Fig. 267 may be used. Often where a number of conduits constitute a multiple run they should be bent to exactly the same radius. An example of this condition is illustrated in Fig. 268 where the bends, *B*, should all be of uniform contour. To insure this uniformity,

a chalk or center-punch mark is made on the conduit at the point where the bend should start. Then when the conduit is placed in the bending machine, this mark is located opposite a pencil line, $N$ (Fig. 267), on the form. Another pencil line

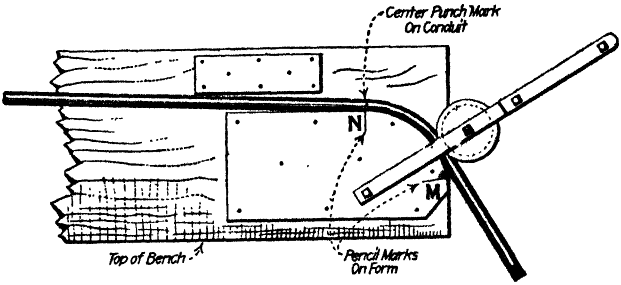



FIG. 267.—Marks on bender to insure duplicate bends.

$M$, is marked on the form at the point to which the bend should extend. In operating the bender the operator pulls the roll only just far enough that the conduit will lie tangent to the mark $M$, and the bend is completed.

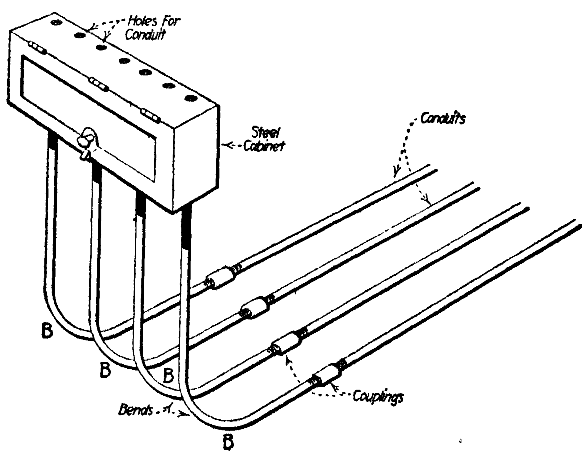



FIG. 268.—Uniformly-bent conduit entering a steel cabinet.

NOTE.—TO MAKE UNIFORM BENDS WITH A BENDING RACK the method illustrated in Fig. 267 may also be used but that shown in Fig. 269 is generally preferred. In this method a spike driven in the top of the bench forms a stop against which the conduit is butted so as to properly locate the bend. If an angle less than 90 deg. is desired, a

mark is placed on block, $B_2$, to indicate where the bend should stop. The conduit is bent by pulling its far end around the form, thus forcing it to the required contour.

**157. A Device For Quickly Forming Bends At The Required Location In The Conduit** may be readily constructed

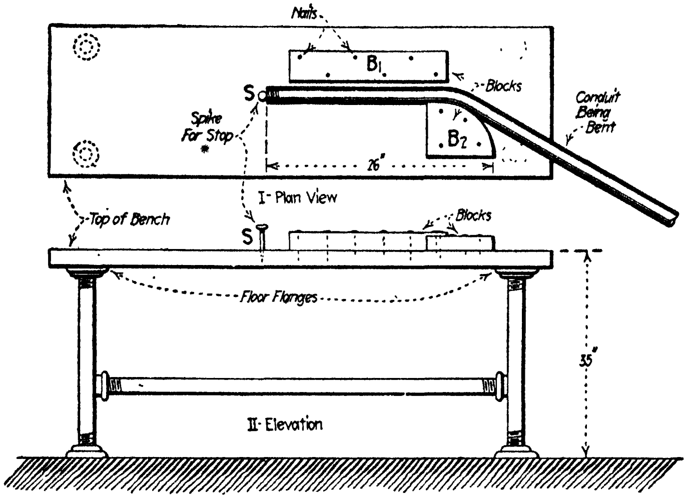



Fig. 269.—Form for bending conduit to exact contour arranged on bench top.

(Fig. 270) by attaching two scales at the side of the bending form. The scales, $P$ and $T$, may be pieces of 2 by 2 dressed

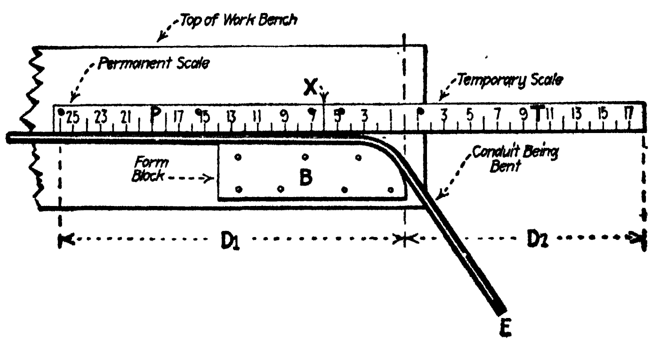



Fig. 270.—Scales mounted on bending bench.

timber. $T$ is removable and extends only to the point $X$. It is thus arranged so that it can, for transportation, be taken from the top of the bench by removing two wood screws. If

left permanently attached to the bench top, it is likely to be broken.

EXPLANATION.—In bending, the conduit is laid in the groove with its end $E$ extending out along $T$ to some point on the scale which has been determined by experiment. Then, without shifting the conduit longitudinally in the groove, $E$ is swung around until the elbow in it has been formed. The scale $P$ may also be of service in locating the bends at the proper positions in the tube. Both $T$ and $P$ may be graduated in inches.

**158. In Forming Uniform Double Bends** a rack constructed as detailed in Fig. 271 can be used to advantage. Often in

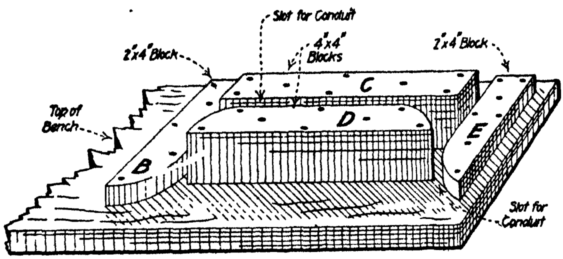



FIG. 271.—Perspective view of form for making special bends.

industrial-plant buildings it is necessary that many lengths of conduit have double bends formed in them (Fig. 272) where the runs pass around a pilaster. If a rack like that of Fig. 271 is constructed such bends can be completed with minimum

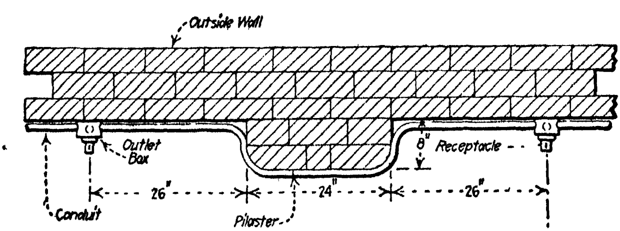



FIG. 272.—Double bend in conduit around a pilaster.

time expenditure. Figure 273 details the dimensions for a rack for forming the double bend required in Fig. 272.

NOTE.—THE PROCESS IN FORMING THE DOUBLE BEND IS THIS: Place the conduit in the groove between blocks $C$ and $D$ (Fig. 274) so

that when the bend is completed the left end, *X*, of the conduit will extend into its outlet box just the right distance. Thereby the cutting off of this end of the conduit is avoided. After this location has once

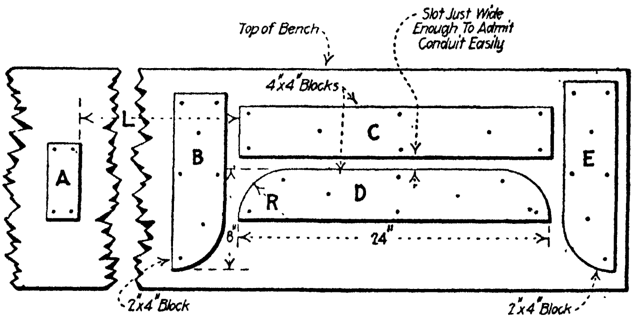



FIG. 273.—Plan view of form for making special bends.

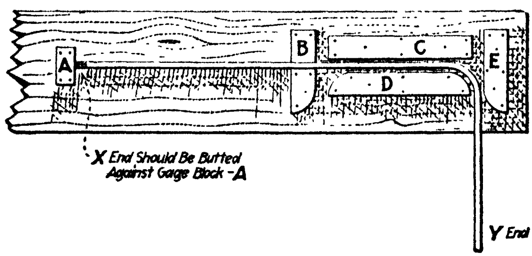



FIG. 274.—First operation in forming double bend.

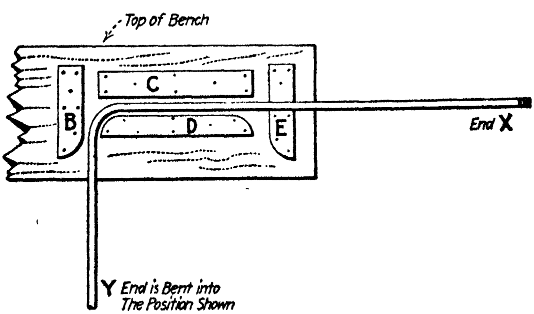



FIG. 275.—Second operation in forming double bend.

been determined, the block *A* is nailed to the bench top which renders a second determination unnecessary. The *Y* end of the pipe is then bent around the form (Fig. 274). Next, reverse the conduit (Fig. 275) so

that the *Y* end lies between *B* and *D* and the *X* end projects over *E*. Now bend the *X* end around *D* (Fig. 276). Finally, the hickey or a

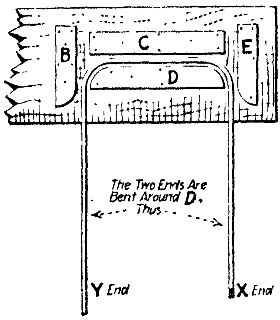



FIG. 276.—Third operation in forming double bend.

bending sleeve is engaged successively on the *X* end and the *Y* end of the conduit and it is bent into the form detailed in Fig. 277. To complete the tube, the *Y* end is cut off to the correct length and threaded.

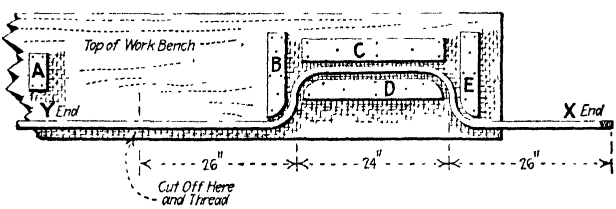



FIG. 277.—Fourth operation in forming double bend.

**159. In Forming A Bend So That The Extending Leg Will Be Plumb** the expedient diagrammed in Fig. 278 has been employed. In the example shown, and in numerous similar cases, an exposed conduit is to be installed on a side wall close to the ceiling and its outer end, *E*, should be bent so as to extend vertically downward. Inasmuch as the ceiling of a room is not always at right angles to a plumb line, the workman cannot be sure of a neat looking job by merely forming a 90-deg. elbow in the conduit. However, if with one leg of the conduit held temporarily in place along the ceiling as shown in the picture, he "plumbs" the extending end, *E*, and bends it to fit, a neat looking job will result. To do this a 2 × 4 timber, *T*, with a V-notch cut in its upper end forms a

brace for the conduit end. A plumb bob, *P*, is arranged to hang down from the apex of this notch to enable the wireman to determine whether or not the extending end, *E*, of the conduit lies plumb. If it does not it can be rebent accordingly.

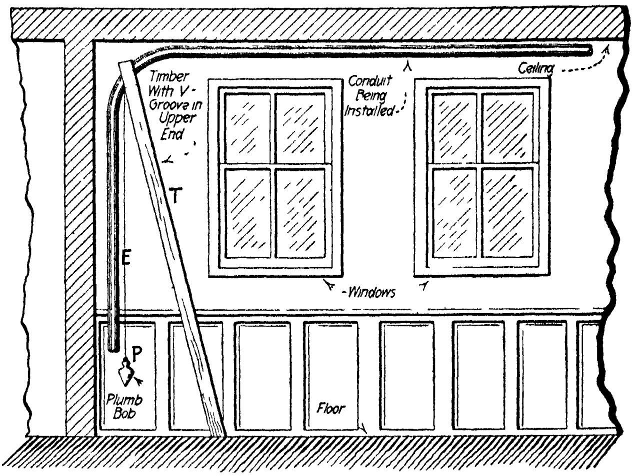



FIG. 278.—Method of making a vertical run plumb.

**160. The Straightening Of Bent Conduit** is a subject of economic importance. On every job a certain amount of conduit is bent incorrectly. Such material may, unless the situation is watched closely, be thrown away or hidden and thereby its value lost. This statement is of particular importance where the conduit is of large diameter. Thus the installation of a straightening machine may be justified, in large shops or for large jobs. With this machine bent pieces of conduit can be straightened at minimum cost.

NOTE.—IT IS USUALLY CHEAPER TO STRAIGHTEN CONDUIT WITH A POWER-OPERATED MACHINE, located in a properly fitted shop than it is for the wiremen to endeavor to straighten the conduit on the job with improvised apparatus. The straightening can often be done on rainy days or at odd times when the men would not be otherwise employed.

**161. The Principle Of Operation Of A Straightening Machine** can best be understood by describing the construction. So far as it is known, no manufacturer regularly makes

a pipe-straightening machine, hence each concern must construct its own. Two of these straightening machines are

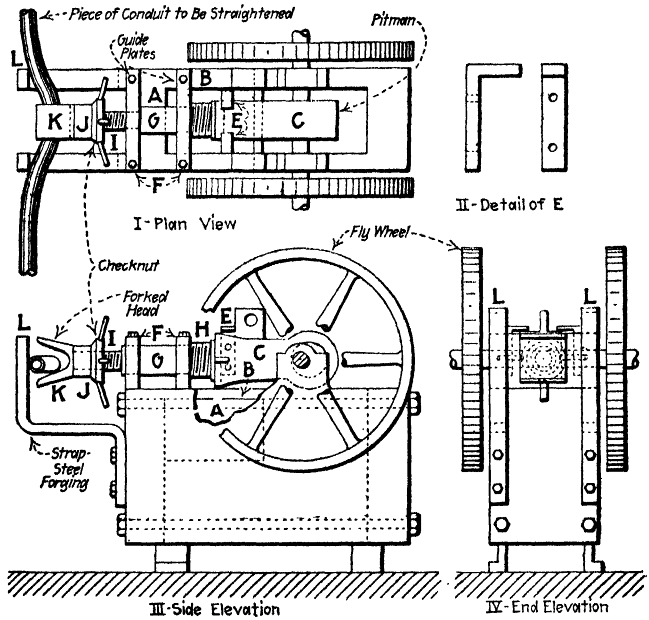



FIG. 279.—Showing how an old rock crusher was modified into a pipe straightening machine.

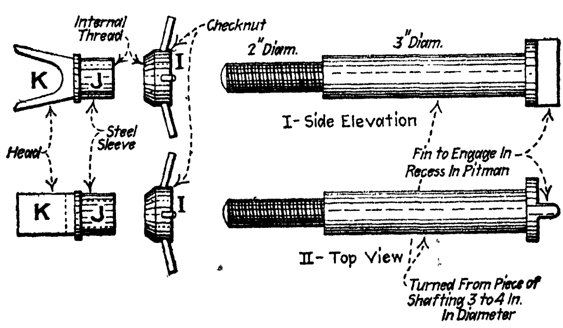



FIG. 280.—Details of the ram "G" in the straightener of Fig. 279.

shown in Figs. 279 and 281. Details are shown in Figs. 280 and 282. Both of these machines were assembled out of old

rock-crusher parts. Each device consists primarily of a ram or plunger which is slowly oscillated longitudinally to or fro by a crank or pitman. The conduit to be straightened is held, by suitably-arranged stops, in front of the ram in such a way that, as the ram comes forward, it pushes against the bend in the conduit and straightens it out.

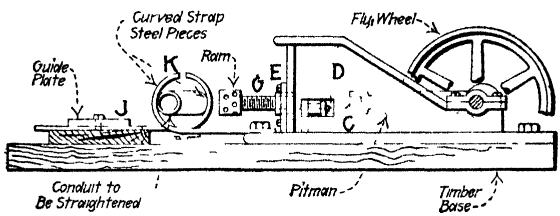



FIG. 281.—A readily-arranged power-driven pipe straightener. The reference letters refer to Fig. 282.

NOTE.—IN ASSEMBLING THE STRAIGHTENER of Fig. 279 the toggles, jaw, and jaw plates were removed from the rock crusher. The frame, pitman, *C*, its shaft and eccentric, the driving pulleys and the fly-wheels were retained. A plate of metal, *B*, was fastened to the top of the frame upon which the pitman, *C*, could work back and forth. Two guides, *E*, were bolted over the top of the pitman to prevent its moving

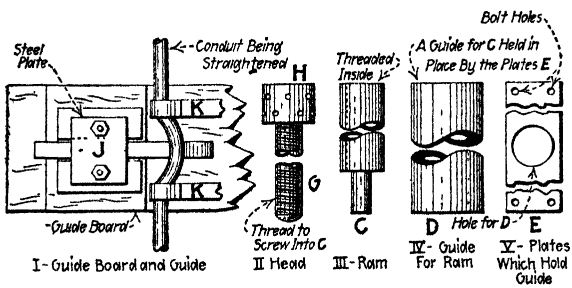



FIG. 282.—Some details of the straightener of Fig 281. (Ram, *C*, is a hollow cylindrical piece of steel which is internally threaded so that piece, *G*, with its head, *H*, will turn in it.)

upwardly. Then the ram, *G* (detailed in Fig. 280) was arranged to move in two guide plates, *F* and *F*, each of which was 6 in. high and 1 in. thick. The ram was turned from a piece of shafting, with a screw thread on one end and a flange, having a fin extending from it, on the other. The fin is provided to engage in the slot in the pitman as shown in Fig. 279-*III*. At the left end of the ram a screw thread was turned to accommodate the checknut, *I*, and the internally threaded sleeve, *J*.

The head, *K*, is fastened to the sleeve by an internal thread (Fig. 280). A spring, *H* (Fig. 279), is provided to insure the return of the ram, when the pitman is drawn to the right-hand position. The strap steel forgings, *L*, hold the conduit while it is being straightened.

Note —A Simple Conduit-Straightening Rack is shown in Fig. 283. This straightener works on the same principle as the conduit-bending racks. All that is required for its construction is a chain or rope tackle and some timber members.

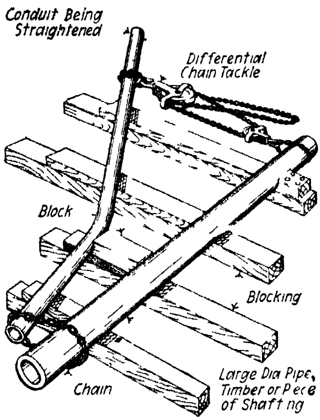



Fig 283 —Straightening conduit with a differential block Conduit may be bent with the same equipment (*Popular Mechanics*).

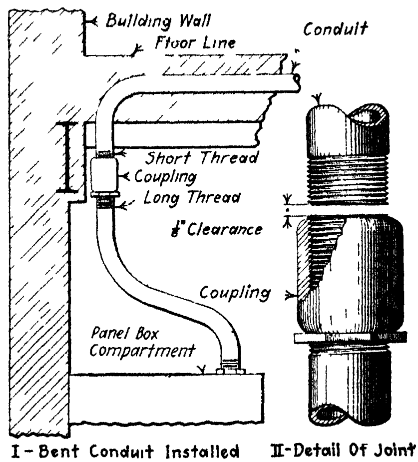



Fig 284.—Running thread joint used for connecting bent conduits.

**162. After The Conduit Is Cut, Threaded And Formed To The Desired Contour,** it is ready to place in the run. However, before placing the conduit in the run, it is good practice, when it contains no bends, to again sight through it (Sec. 122) to see if any burrs now project from its ends (Fig. 170). Plain couplings (Fig. 250) are, except as noted below, used for joining rigid conduit. Where a piece of conduit has to be inserted in a run, or when bent conduit must be joined (Fig. 284) special couplings, as described in Sec. 58, or running threads must be used. Running threads being cheaper to install than special couplings are very frequently employed for this purpose. They are, however, not so satisfactory in moist places nor in concrete, since they are not waterproof.

This disadvantage may be at least partially eliminated by packing the joint with asphaltum.

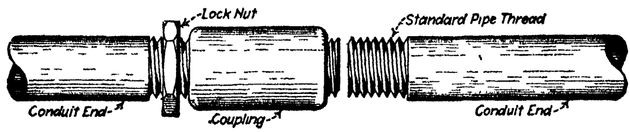



FIG. 285.—Running thread before conduits are joined together.

NOTE.—TO MAKE A RUNNING THREAD JOINT (Fig. 285), the thread on one length of the conduit is cut sufficiently long so that the entire length of the coupling together with a locknut can be screwed on it, while

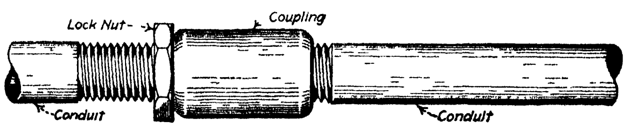



FIG. 286.—Running thread joint complete with locknut.

the adjacent piece of conduit is being fitted into position. This adjacent length has the usual short length of thread. After both lengths of conduit are in position, the coupling is turned until it wedges up tightly on

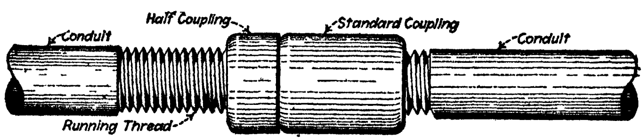



FIG. 287.—How a locknut may be made from a piece of conduit coupling.

the short thread. The locknut is then abutted firmly against the coupling (Fig. 286), to hold it securely in place, as it is apt, because of the long thread, to fit loosely on the conduit. A short piece cut from a

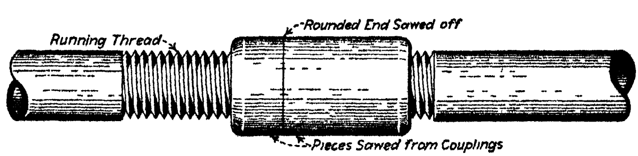



FIG. 288.—A neat form of running thread joint.

coupling may be used instead of the standard locknut (Fig 287). Where a neat job is desired, the rounded end of the standard coupling may be sawed off (Fig. 288) so that the surface of the improvised coupling locknut and that of the coupling will lie flush.

NOTE.—WHEN JOINING FLEXIBLE CONDUIT either to rigid conduit or to another piece of flexible conduit, box connectors and a rigid-conduit coupling can be used (Figs. 289 and 290). The flexible conduit couplings (Sec. 59) are also employed for this purpose but are generally not as satisfactory.

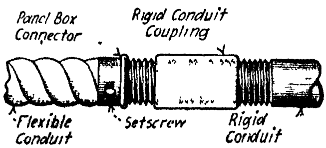



FIG. 289.—Joining flexible conduit to rigid conduit by using a panel-box connector and a rigid-conduit coupling.

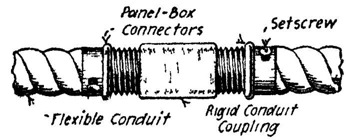



FIG. 290.—Joining two flexible-conduit ends by using two panel-box connectors and a rigid-conduit coupling.

**163. Conduit Ends Should Be Plugged Or Closed** (see Sec. 61), after installation and prior to the installation of the conductors, to prevent foreign materials from falling into the conduit and clogging it. Wooden plugs, discs and bushings (Fig. 35), or closed bushings (Fig. 33) may be used for this purpose. Closed bushings are in most cases the best to use. They have the advantage over discs and bushings, in that the bushings do not have to be removed when the conductors are to be pulled in. They cannot be left in a conduit when the run is continued and thus block up the raceway as the wooden plugs sometimes do.

**164. Additional Holes Often Have To Be Made In Steel Boxes** to allow conduit runs, which were not originally contemplated, to enter the boxes. Such holes can be cut by some one of several different methods. The most common method is to cut out the hole with a cold chisel and a hammer, using a hardwood block, under the sheet metal, to cut on. This method batters up the box and does not provide a neat looking job. Another way is to drill in the box (Fig. 291) a circle of holes, the circle having the same diameter as the hole required, and then to knock out the disc which is thus formed with a hammer. The projections remaining (Fig. 291-*IV*) may or may not be filed away. A quicker and easier method (Fig. 292), if the sheet metal is not too thick, is to use a round steel punch, which has its end ground off squarely, of the same size as the hole desired. Then if the box is supported flat on a hardwood

block directly under the hole location and the punch is properly placed (Fig. 292), a clean hole can be made with a moderate blow of the hammer. The end grain of the block must be used to punch on. Various sized punches must be used for the different sized holes.

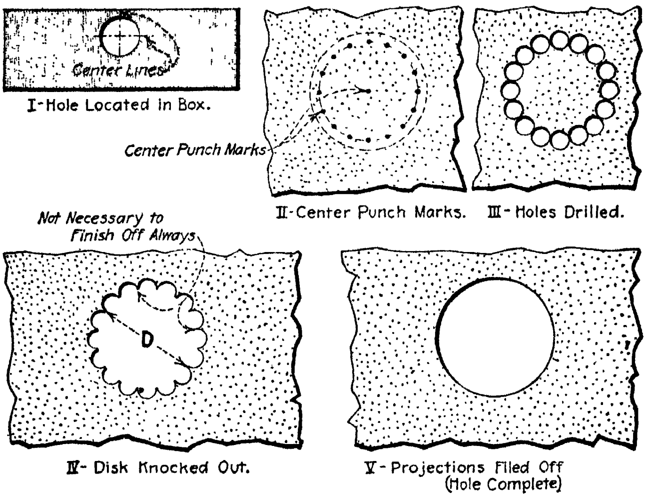



FIG. 291.—Showing how to make a large hole in a steel box by drilling smaller holes therein.

NOTE.—A TYPE OF COMMERCIAL HOLE CUTTING DEVICE is shown in Figs. 293 and 294. This tool, known as the "Jiffy Adjustable Cutter," will bore a clean annular hole in a short time. A 1½- or 2-in. hole for conduit can be cut in a sheet steel conduit box of 12 to 16 gage in less than 5 minutes. A 3-in. hole has been cut through 16 gage steel in 3 minutes but this speed might not be attained continuously. The cutter is made in three sizes, each of which is adjustable so as to cut holes of various diameters; with the three sizes, holes from 1¼ in. to 6 in. in diameter can be cut. Special knives can be obtained which will cut material from ½ in. to 2 in. in thickness. In using the cutter, a ⅜-in. hole must first be drilled through the box into which hole the guide is inserted. The lower nut must then be tightened so that the knives are held firmly against the surface which is to be cut. The knives are easily adjusted for a hole of any diameter up to the capacity of the cutter. The ratchet wrench is then

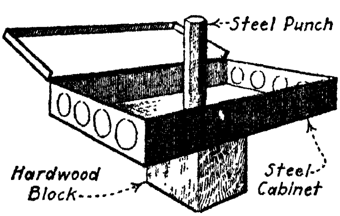



FIG. 292.—Punching hole in a steel cabinet with a steel punch.

attached. The knives are rotated thereby on the surface which is to be cut and sufficient pressure is exerted on them by screwing down the knurled nut. This forces them to cut the material.

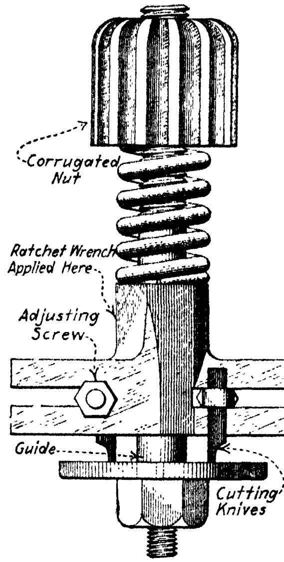



FIG. 293.—The "Jiffy" adjustable cutter. (Distributed by *Koch & Sandidge, Chicago, Ill.*)

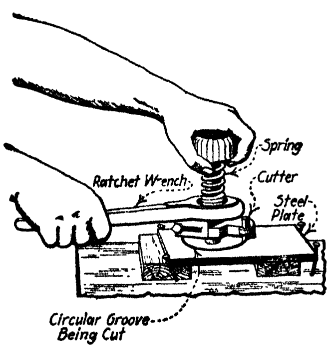



FIG. 294.—Close up view of Jiffy Cutter showing method of tightening knives.

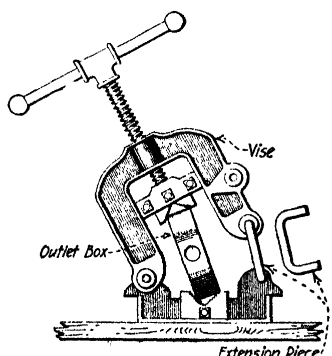



FIG. 295.—Showing how vise may be used to hold an outlet box. The extension piece may be made from $\frac{3}{8}$ in. round reinforcing steel.

**165. Holes In Conduit Boxes Often Have To Be Enlarged.**—This can be done by gripping the conduit box in a vise (Fig.

295) and reaming out the holes with a pipe reamer. Holes in cabinets (Fig. 296) may be enlarged similarly. For cast-iron conduit fittings and boxes, when extra hard ones are encountered, it is well to anneal them before reaming. To do this heat the box to a high temperature in a forge and then cover it with fine coal dust and allow it to cool slowly.

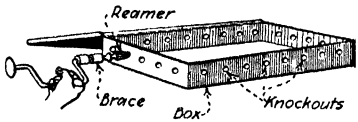



Fig. 296.—Enlarging a knockout hole in a cabinet with a reamer.

Note.—A Conduit Smaller Than The Knockout Hole In The Conduit Box must often be used. Then when conduit boxes with ¾-in. knockouts are used, it is frequently necessary to run ½-in. conduit into one of the knockout holes. The ½-in. conduit can be made perfectly secure in a ¾-in. knockout hole (Fig. 297) if two large washers, which have the holes in them reamed out to proper diameter, are used,

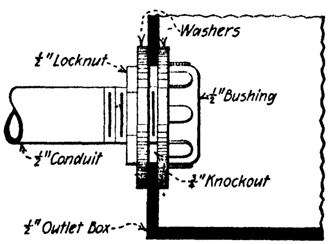



Fig. 297.—Method of fastening a ½-in. conduit in a ¾-in. knockout hole.

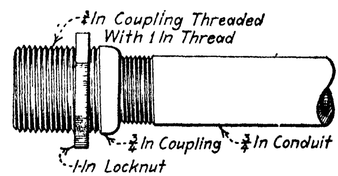



Fig. 298.—Method of fastening a ¾-in. conduit in a 1-in. knockout hole.

one on each side of the box, with the regular locknut and bushing. Also a ¾-in. conduit may be secured to a conduit box which has 1-in. knockout holes (Fig. 298) by screwing the conduit into a ¾-in. coupling, threading the coupling with a 1-in. male thread, and then fastening the coupling to the box with a 1-in. locknut and bushing.

## QUESTIONS ON DIVISION 4

1. What tools are required for the manipulation and installation of conduit? Should good tools be used? Why?

2. Where should the vise for a conduit installation be located? What factors should be considered?

3. Describe and make a sketch of a method of fastening a vise to a column.

4. What are portable vise stands? State their advantages over an ordinary stationary vise. For what types of installations is it particularly adapted?

5. Make a sketch of three methods whereby a bench vise can be converted into a pipe vise.

6. Make a sketch of an improvised pipe vise made from conduit materials.

7. Describe and illustrate with a sketch the method of measuring the length of conduit to connect two fittings.

8. Describe the method of measuring the length of conduit required to connect an existing fitting with a new fitting to be located in a parallel existing run.

9. Describe the graphic method of determining the length of conduit required to connect two 45 deg. fittings.

10. Explain how a small triangle may be used for locating the center of the pipe hole of a fitting.

11. State how the length of conduit required for a U-bend may be determined.

12. Describe the six-foot rule method of measuring an angle in a confirmed space.

13. Show how a two-foot rule can be used for laying out and measuring angles.

14. State the procedure which should be followed in cutting conduit.

15. What tool is generally used for cutting small-sized rigid conduit and describe how it should be used? Should an ordinary pipe cutter be used and why?

16. What tools may be used for cutting large-sized conduit?

17. Describe the method of cutting flexible conduit.

18. Why should the ends of conduit be reamed? What tools are generally used?

19. Give the general method of threading rigid conduit and describe the operation fully. State the points which must be observed to obtain a good thread.

20. When are power therading machines used and what are their advantages? Describe the portable power drive.

21. Describe a method of making short nipples.

22. What type of wrench is most frequently used for conduit installation?

23. Explain the method of using a stillson wrench.

24. State the advantages of the chain wrench.

25. Describe several ways in which a monkey wrench may be used as a conduit wrench.

26. Name four classes of conduit benders and explain each. Give the applications of each class.

27. When is a conduit hickey used and what are its advantages?

28. Enumerate three kinds of improvised hickeys and state which is the most commonly used.

29. What are the disadvantages of the pipe-tee hickey?

30. Give two types of commercial hickeys and describe each.

31. Draw a sketch of and explain the construction of an improvised bending rack for large conduits.

32. Show how a bending rack may be constructed from two blocks, two cleats, or two pulleys.

33. Illustrate the principle of operation of a twin-spool bending rack. Draw a sketch of a twin-spool rack for forming short-radius bends.

34. Explain the operation of a shaft-and-ring conduit bender.

35. Show several ways in which a block and tackle may be used in connection with a bending rack.

36. How can a pipe-tee hickey be used as a conduit bending rack?

37. Give the general construction of pressure benders.

38. Enumerate the advantages of the roll bender. For what work is it particularly well adapted?

39. Draw sketches of three different types of improvised roll benders.

40. Describe the Pedrick bending machines and their operation.

41. Describe the method of making a right-angle bend with a hickey. With two hickeys.

42. Show how a short radius bend can be made in conduit.

43. Describe the method of making parallel bends.

44. How may short-radius end bends be made?

45. Describe two methods of forming offset bends.

46. Give a method of forming a number of duplicate bends with a roll bender.

47. Describe a method whereby uniform double bends may be made.

48. Explain the principle of operation of a straightening machine and describe the construction of one made from a rock crusher.

49. How may rigid and flexible conduit be connected?

50. Explain several methods of forming holes in steel boxes.

# DIVISION 5

## INSTALLING CONCEALED CONDUIT

**166. Concealed Wiring Should Be In Conduit** when it is installed in masonry construction of any sort such as brick, concrete, or terra cotta (hollow building tile). In certain localities where building ordinances so require it, concealed wiring in wooden-frame construction must also be in conduit. The procedure in the installation of concealed conduit in buildings of the different types of construction varies somewhat. It is the purpose of this division to present the procedure and methods employed in installing concealed conduit in buildings of these various types.

NOTE.—IN CONCEALED CONDUIT WORK, ALL CONDUIT BOXES MUST BE "ACCESSIBLE." They must be in such places that a wireman may gain access thereto without damage to any part of the building. Thus, junction boxes may be installed in an attic that has sufficient head room but which is reached only by a portable ladder and a permanent hatch (National Electrical Code).

**167. The Thickness Of Plaster And Of Lath And Plaster** should be known by the wireman when he is installing conduit boxes in roughing in. Formerly the total thickness of the lath, the rough plaster and the finish plaster coats averaged, probably, in the neighborhood of 1 in. But modern practice is to put the coats on as thin as possible. Consequently, they seldom if ever have a total thickness greater than 7/8 in. and they usually are about 3/4 in. thick. The rough and finish coats of plaster which are ordinarily applied on terra cotta tile or on concrete surfaces are respectively about 5/8 in. and 1/8 in.; this gives a total thickness for both of about 3/4 in.

**168. In Installing Concealed Conduit In Concrete Buildings With Wood-Covered Floors,** either of two methods may be employed (1) *Placing the conduit and boxes before the concrete floor slabs are poured.* (2) *Making provision for placing the conduit and boxes after the floor slabs have been poured.* The

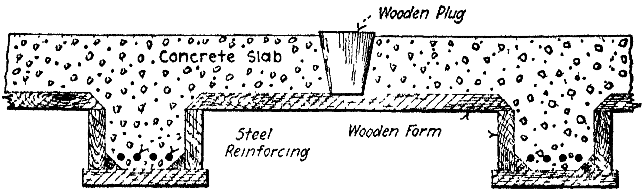



FIG. 299.—Method of providing space for later placement of conduit in building which has wooden floors on concrete slabs.

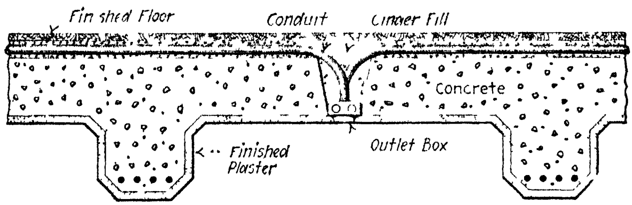



FIG. 300.—Final position of conduit and outlet box in hole provided as shown in Fig. 299.

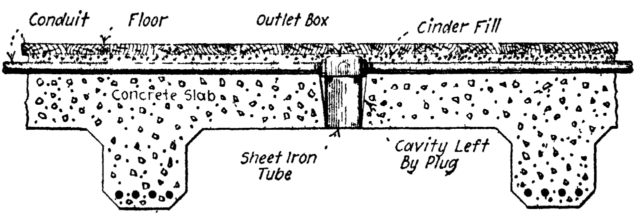



FIG. 301.—Another method of placing conduit and outlet box in the hole provided in Fig. 299. This method avoids sharp bends in the conduit.

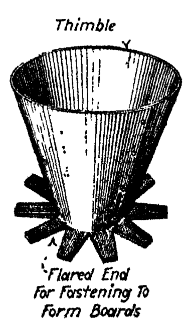



FIG. 302.—Thimble which may be used instead of the block shown in Fig. 299.

first method is, in general, the better and is recommended for cases where it may be employed. If, however, the wireman is unable to attend to a certain job until the concrete workers are nearly ready to proceed with the pouring, or if some other reason requires it, wood blocks (Fig. 299) may be fastened to the form boards at the outlet locations so that the conduit and box may be later installed as shown in Fig. 300 or as in Fig. 301. The wood blocks should, at the lower ends, be somewhat larger than the size of the outlet boxes and should have a good taper. A sheet-iron thimble (Fig. 302) may be used to form the hole in the concrete instead of the block if desired.

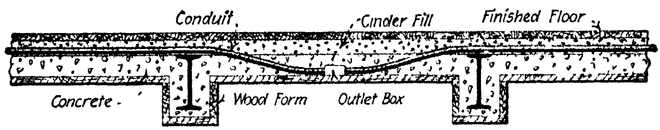



Fig. 303.—Position of conduit and box in floor. Conduit placed before pouring of floor slab. Compare with Fig 300.

Note.—Placement Of Conduit And Boxes Before Pouring Is Generally More Economical than method (2) above. Cases might arise, however, when method (2) would be more economical than method (1). So far as the ceiling outlets themselves are concerned, it is evident that providing spaces with wooden plugs or thimbles is just so much superfluous work. Furthermore, much sharper bends are required with this method than when the conduit is placed before the pouring of the slabs (see Fig. 303).

**169. In Running Conduit In Concrete Floor Slabs, The Following Rules** may safely be employed: (1) *Always place conduit just above the lowest reinforcing rods,* or in the same plane if the conduit runs parallel to the rods and is no larger in diameter than are the rods. (2) *Try to limit the conduit size* so that its outside diameter is not more than one-fourth or one-third the thickness of the slab. (3) *Try, where possible, to run the conduit parallel to the reinforcing rods* in slabs which have one-way reinforcement. (4) *Run all conduits which must be at right angles to the reinforcement, along the center of the slab.* That is, if a slab is supported from beams, run the conduit half-way between the beams; not near one beam. The conduit may, however, be run within the beam.

Note.—Little Is Known Concerning The Weakening Effect, If Any, Of Conduit In Concrete Construction. To determine the

effects would require experiments The rules of Sec. 169 above, however, are based on the principles of concrete design and may be safely followed. They are so formulated that conduit installation in compliance with them will not weaken the building construction.

**170. The Method Of Fastening Conduit Boxes To Rigid Conduit** is shown in Figs. 304 to 307. First, assuming that the conduit is threaded for about ½ in. from its end, a locknut

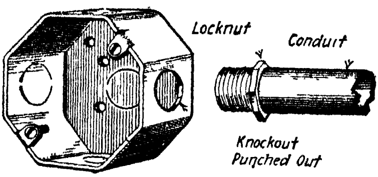



FIG 304 —*First step*, box hole knocked out and locknut run on conduit end.

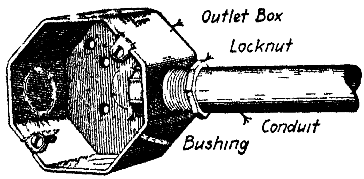



FIG 305 —*Second step*, conduit end in hole and bushing on conduit end.

is screwed onto the threads as far as it will go (Fig. 304). Next see that there are no burrs or bits of enamel around the knockout hole in the box. Then the conduit end is inserted into the knockout opening of the conduit box and the bushing is started onto the thread (Fig. 305). After the bushing is screwed on as far as it will go (Fig. 306), the locknut is screwed back toward the box until the box is held firmly

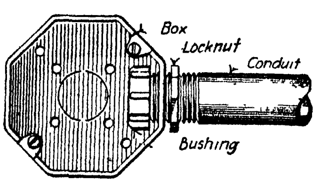



FIG. 306 —*Third step*, bushing set up tight on conduit end.

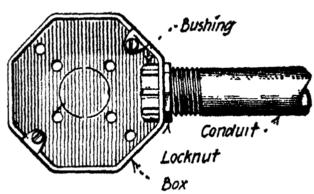



FIG 307.—*Fourth step*, conduit pulled back until bushing bears on box side and locknut set up tight.

between the locknut and bushing (Fig. 307). Should it become necessary at any time, to leave the bushing standing away from the inner surface of the box (as in Fig. 308), the fastening should be made secure by inserting an additional locknut inside the box as in Fig. 309. Wiring inspection departments in certain cities require the use of two locknuts in every case.

NOTE.—THE CONNECTION OF THE CONDUIT TO EACH CONDUIT BOX MUST BE ELECTRICALLY CONTINUOUS.—To insure this condition, the locknut and the bushing, or both locknuts if two are used, must set up snugly against the metal of the conduit box. In certain cities the inspection departments require that the enamel must be scraped from painted boxes around the knockout hole so that the locknut and bushing will make good metallic contact with the box.

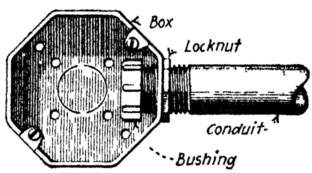


FIG. 308.—Conduit cut too long; improper connection between conduit and box (see Fig. 309).

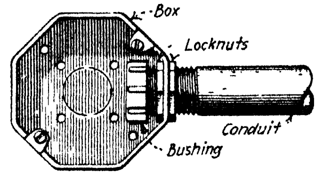


FIG. 309.—Proper connection between box and conduit when conduit is cut a little too long.

**171. The Methods Of Fastening Conduit Boxes To Flexible Conduit** are shown in Figs. 310 to 313. After cutting off the conduit squarely to the proper length and reaming the end, a connector should be slipped over the end as far as it will go (Fig. 310). The connector should then be screwed or clamped tightly to the conduit (Fig. 311). Next see that there are no burrs or bits of enamel around the knockout hole in the box. Then insert the connector into the box (Fig.

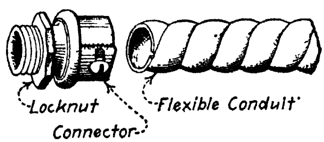


FIG. 310.—*First step*, connector ready for insertion over conduit end.

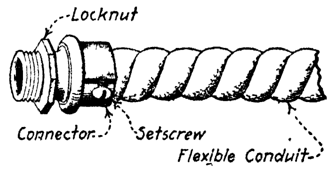


FIG. 311.—*Second step*, connector clamped on conduit end.

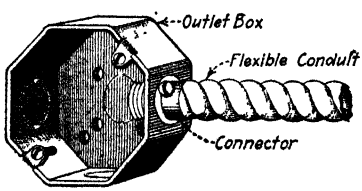


FIG. 312.—*Third step*, connector inserted into box hole with shoulder of connector bearing against box side.

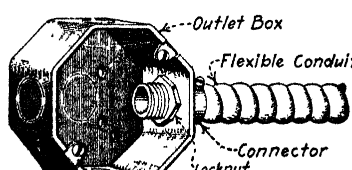


FIG. 313.—Connecting flexible conduit into a box. *Fourth step*, locknut on inside of box set up tightly.

312) and screw a locknut onto it until it fits snugly against the box (Fig. 313). Then screw on a bushing (unless the connector is of such type as does not require a bushing). If desired, the locknut may be placed outside of the box and only the bushing inside as shown in Fig. 314. When an elbow-clamp connector is used, the finished connection appears as shown in Fig. 315.

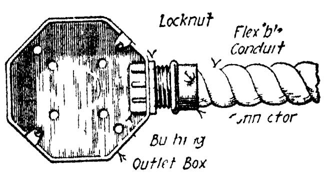



FIG 314 —Showing connection of flexible conduit to an outlet box, using a bushing and locknut on the connector.

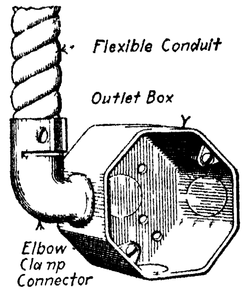
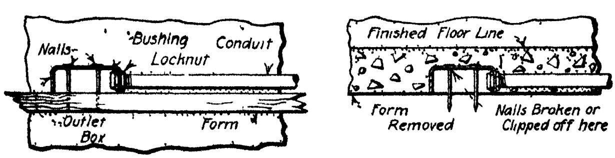



FIG 315 —Elbow-clamp connection between flexible conduit and an outlet box

**172. Conduit Boxes May Be Fastened To Forms For Concrete** with nails (Fig. 316) or with wires, or screws (Fig. 317). Each box should be held firmly to the boards so that it cannot fill with concrete. If the concrete should flow under the conduit boxes while it is being poured, the boxes and sometimes the conduit will be filled with concrete and,




I-Outlet Box Secured to Form II Form Removed

FIG 316 —Attaching outlet boxes to form.

although they may usually readily be located by the protruding nails or wire, considerable time may be wasted in removing the concrete from their interiors.

NOTE.—TO PREVENT THE BOXES FROM FILLING WITH CONCRETE, some wiremen stuff the boxes with crumpled paper before nailing them finally to the form boards (see Fig. 326). Some wireman bore a 1-in.

hole in the form boards at each conduit-box location so that the boxes and conduit cannot fill with semi-liquid concrete; this appears to be always a good plan. After the form boards have been removed, the protruding nails or wire must be cut off flush with a pair of nippers or diagonal pliers.

NOTE.—A POCKET COMPASS MAY BE USED TO LOCATE HIDDEN CONDUIT BOXES which have been accidentally covered with plaster or

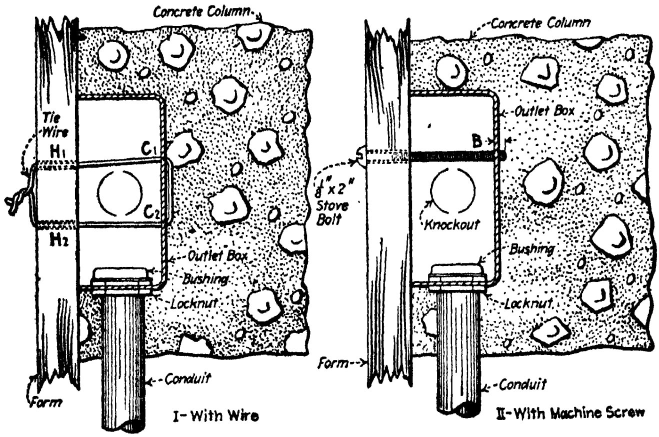



FIG. 317.—Showing how side outlet boxes may be supported to concrete forms. In arrangement *I* two holes, $H_1$ and $H_2$, are bored through the form boards at the location where the box is to be placed. The box is then tied securely by a wire which is twisted at its ends as shown. After the form has been removed these wires can be bent off or cut off with a pair of pinchers at $C_1$ and $C_2$. In arrangement *II*, a stove bolt is fastened into one of the holes in the bottom of the box. The screw should be of such length that *B* does not exceed about 1/8 in.

concrete. The position of each side and the top and bottom of the box can usually be determined by moving the compass around slowly, close to wall at the place where the box should be. Move the compass first from one side to the other and then up and down. Mark with a pencil each course where the compass needle shows the greatest deflection. This method may not be successful where there is reinforcing still in the plastered surface. All iron and steel objects should be removed from the pockets when using the compass.

**173. Conduit Boxes May Sometimes Effectively Be Held To The Form Boards With A Pipe Coupling, Nipple And Locknut** (Fig. 318). Where the boxes are to be equipped with *fixture studs* this is often an economical method. A hole for the nipple is bored through the form at each box location.

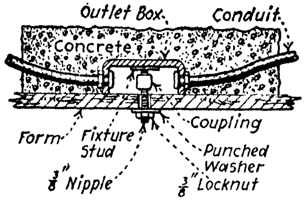



FIG. 318.—Conduit box held to form with a pipe nipple and locknut.

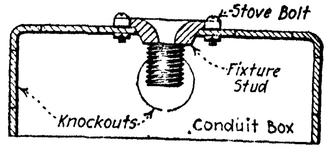



FIG. 319.—A method of attaching a fixture stud which is to support heavy loads. The stud is inserted through the center knockout of the box.

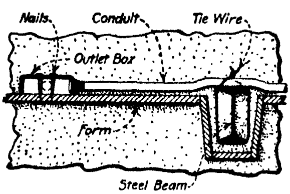



FIG. 320.—Attaching conduit to beam.

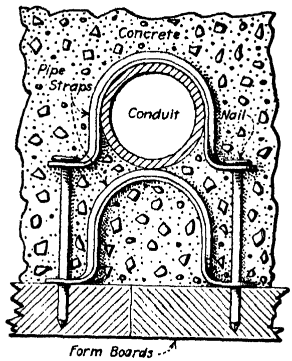



FIG. 321.—Pipe-strap riser to hold conduit from form boards. Pipe straps may be less expensive than tie wires if labor is expensive.

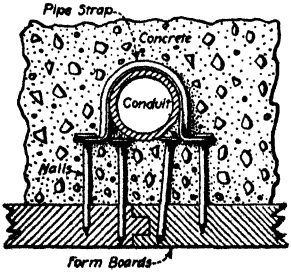



FIG. 322.—Conduit held away from form board with nail risers. A wire tie is about as satisfactory but may cost more in installation time than a pipe strap.

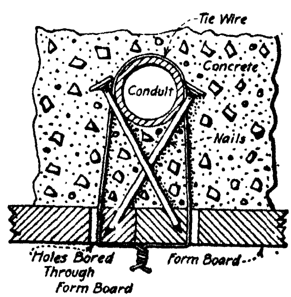



FIG. 323.—Attachment to form board with crossed nails and through tie wire.

The box with the coupling and nipple "made up" on the fixture stud is put in position on the form, the nipple extending through the hole. Then a locknut is screwed up tightly against the washer, holding the box securely in position. The

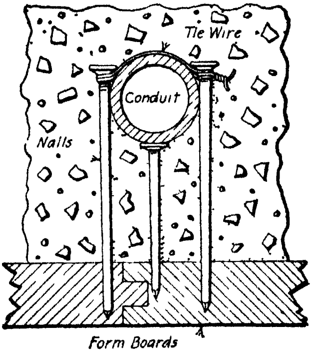



FIG. 324 —Attachment with three vertical nails and top tie wire.

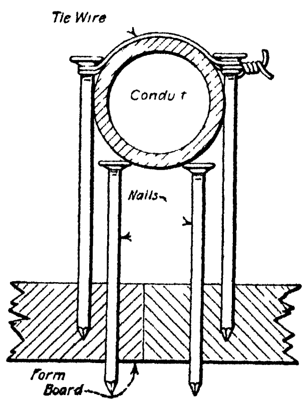



FIG 325 —Attachment with four vertical nails and tie wire.

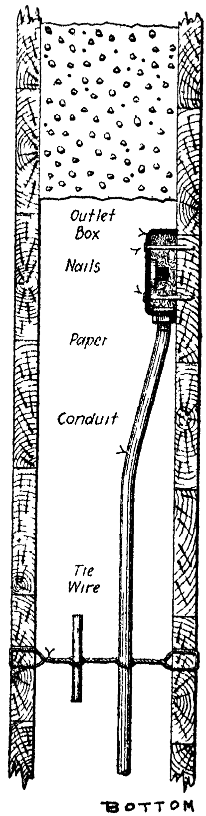



FIG. 326.—Showing methods of supporting conduit and outlet box in vertical wall-form.

conduits must be made up into the box before it is fastened in position. At the time of the removal of the form the nipple, coupling, locknut and washer are taken down for use on the next job.

**NOTE.—A VERY STRONG METHOD OF ATTACHING FIXTURE STUDS is shown in Fig. 319. The base of the stud lies on the outside, instead**

of on the inside, of the box. This relieves the stove bolts, which are often twisted almost in two in screwing them up, of any stress due to the luminaire load. Inspection departments in certain cities require that all fixture studs be installed as shown in Fig. 319; the stud shown in Fig. 50 cannot be installed in any other way.

Note.—The Conduit Itself Must Frequently Be Fastened Or Supported In Concrete Forms so as to prevent its being moved by other workmen and often to prevent its lying directly against form boards. Where conduit passes over steel beams it may be fastened as shown in Fig. 320. When steel reinforcing rods are present, the conduit may frequently be supported by and fastened to these rods. To prevent the conduit from unduly weakening a concrete slab and to permit the concrete to flow under it, the conduit must often be supported at a slight distance from the form board. Different methods of supporting conduit form boards are shown in Figs. 321, 322, 323, 324, 325, and 326. Often, if they are available, pieces of stone, brick or hollow tile may be used to hold the conduit away from the form board.

**174. Outlet-Box Hangers Should Be Provided, When A Heavy Luminaire Or Ceiling Fan Is To Be Supported From The Box,** as is suggested in Figs. 327 and 328. The nipple

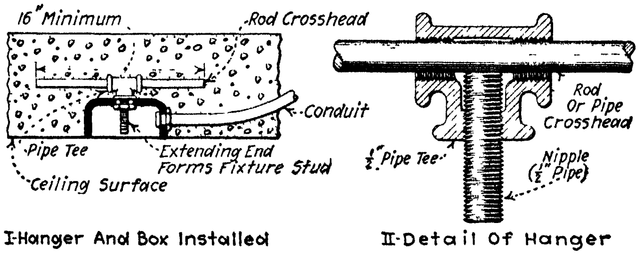



Fig. 327.—An improvised conduit-box hanger to be used where a heavy fixture is to be supported.

should, preferably, be of ½-in. pipe. It may be "bushed" up or down as is necessary to take the fixture stem, by using a pipe-fitting reducer. The nipple should extend down to the bottom of the conduit box so that the reducer can be screwed on readily with a pipe wrench. Where the floor is sufficiently thick, the nipple should be longer than indicated in Fig. 327, so that the crosshead will lie well toward the surface of the slab. See also Sec. 65 on conduit-box hangers. A hanger may be improvised on the job as shown in Fig. 329.

Note.—Outlet-Box Hangers Should Be Assembled In The Shop complete so that they can be attached to the box on the job with a

minimum of labor. If an endeavor is made to assemble them on the job, the small parts are liable to be lost.

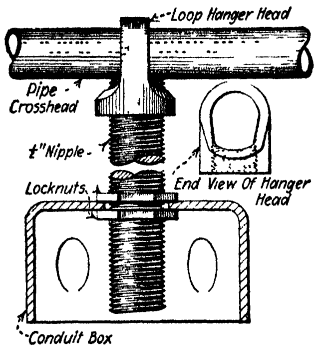



FIG. 328.—*Thomas & Betts* conduit-box hanger arranged for a heavy-fixture outlet.

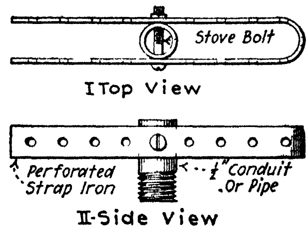



FIG. 329.—Improvised conduit-box hanger having a perforated strap-iron crosshead.

**175. The Use Of Pipe Elbows Instead Of Conduit Elbows Or Bends** (Fig. 330) is permitted in concrete floor slabs by many inspection departments when there is insufficient room in the concrete for the installation of the standard elbows or bends. If the pipe fittings are used, they should be galvanized and have all burrs and pins removed. However, where conditions permit, a box located in the lower face of a beam may be installed by using standard bends as in Fig. 331.

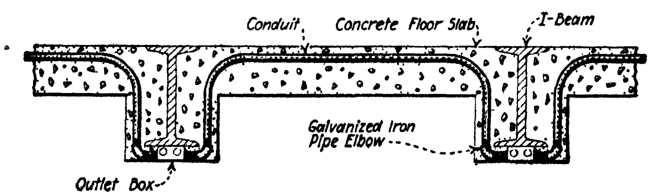



FIG. 330.—Pipe elbows used under an I-beam where space is restricted.

**176. A Method Of Supporting Conduit Boxes In Steel Concrete-Columns Forms** is shown in Fig. 332. After the steel forms have been erected, but before the reinforcing steel has been placed in them, the conduit box is set in the required location against the side of the form, the feed conduit being made up into the box. Then the box and the conduit are wired (Fig. 333) to the form. It is necessary to drill small

holes through the sheets of the metal forms with a small-diameter drill to permit of the tie wires being placed. A hole

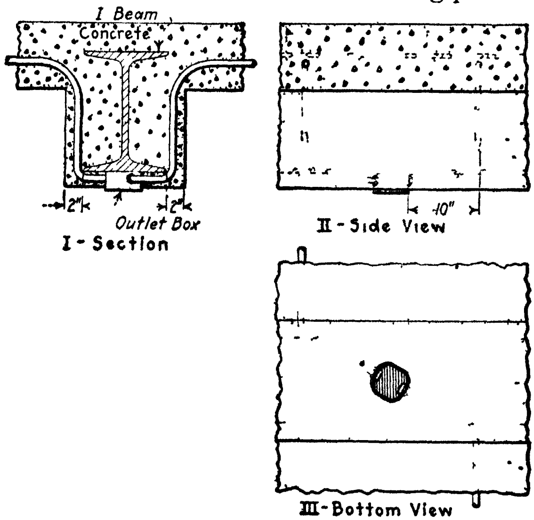



Fig. 331 —Outlet box installed in restricted space, conduit bends of standard radius being used

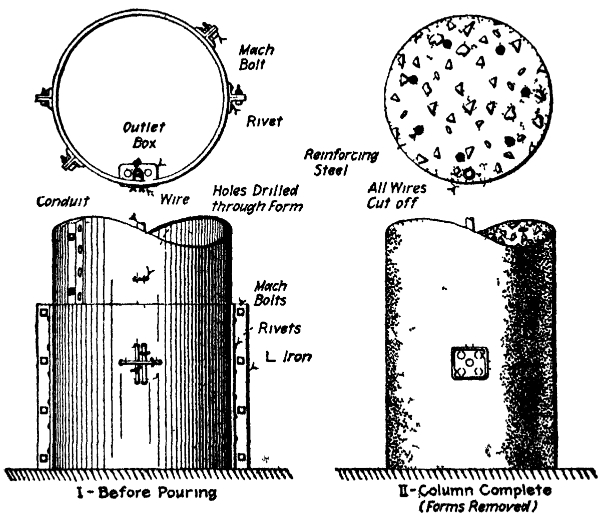



Fig. 332 —Setting conduit outlet box in concrete column

an eighth of an inch (⅛ in.) in diameter is of ample size. As a caution, great care should be taken, especially for boxes

minimum of labor. If an endeavor is made to assemble them on the job, the small parts are liable to be lost.

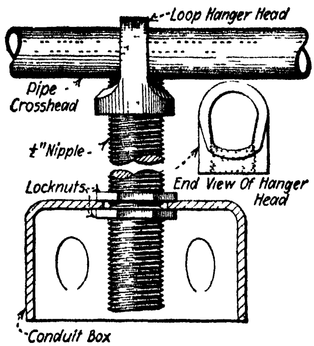



Fig. 328.—*Thomas & Betts* conduit-box hanger arranged for a heavy-fixture outlet.

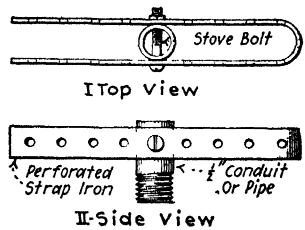



Fig. 329.—Improvised conduit-box hanger having a perforated strap-iron crosshead.

**175. The Use Of Pipe Elbows Instead Of Conduit Elbows Or Bends** (Fig. 330) is permitted in concrete floor slabs by many inspection departments when there is insufficient room in the concrete for the installation of the standard elbows or bends. If the pipe fittings are used, they should be galvanized and have all burrs and pins removed. However, where conditions permit, a box located in the lower face of a beam may be installed by using standard bends as in Fig. 331.

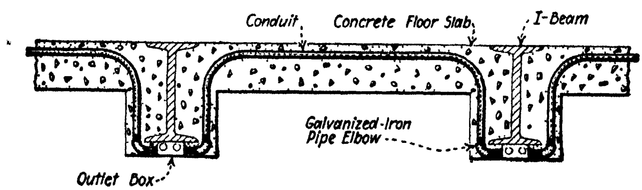



Fig. 330.—Pipe elbows used under an I-beam where space is restricted.

**176. A Method Of Supporting Conduit Boxes In Steel Concrete-Columns Forms** is shown in Fig. 332. After the steel forms have been erected, but before the reinforcing steel has been placed in them, the conduit box is set in the required location against the side of the form, the feed conduit being made up into the box. Then the box and the conduit are wired (Fig. 333) to the form. It is necessary to drill small

holes through the sheets of the metal forms with a small-diameter drill to permit of the tie wires being placed. A hole

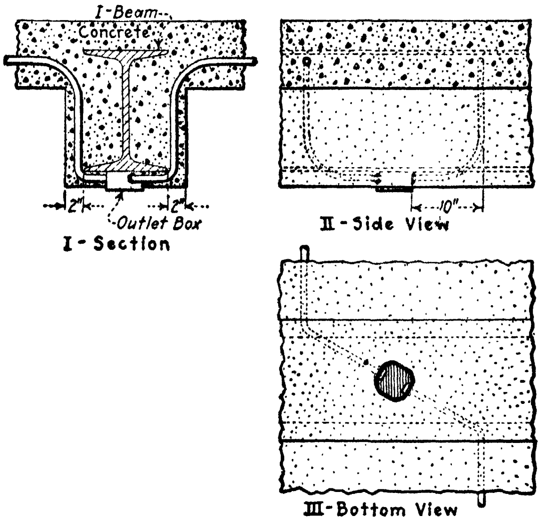



FIG. 331.—Outlet box installed in restricted space, conduit bends of standard radius being used.

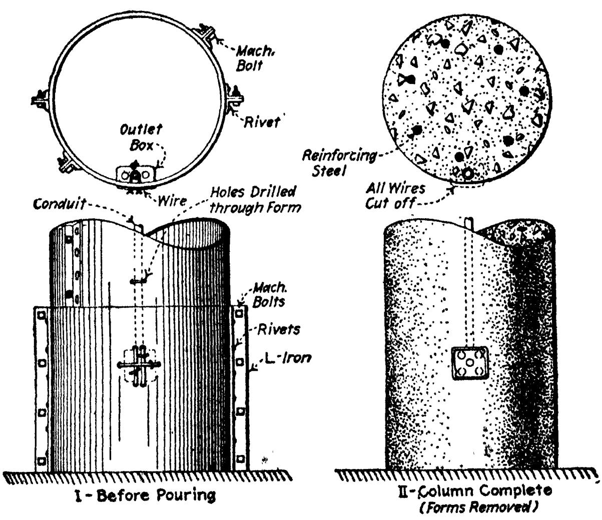



FIG. 332.—Setting conduit outlet box in concrete column.

an eighth of an inch (⅛ in.) in diameter is of ample size. As a caution, great care should be taken, especially for boxes

on vertical surfaces, to insure that the conduits in the boxes are firmly fastened in the form so that there cannot be shifting in the form when the concrete is being poured and so that the concrete cannot leak in. It is always a wise precaution to stuff vertical boxes full of paper.

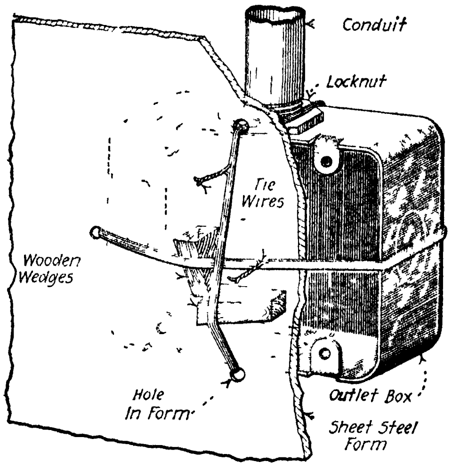



Fig. 333.—"Close up" of conduit box wired to column steel form.

**177. Vertical Runs Of Conduit In Concrete Buildings,** especially large conduits, are frequently set in *chases* (Fig. 334) or in *wire-shafts.* It is not customary to install the main *risers* which are of large-size conduit, until all of the concrete

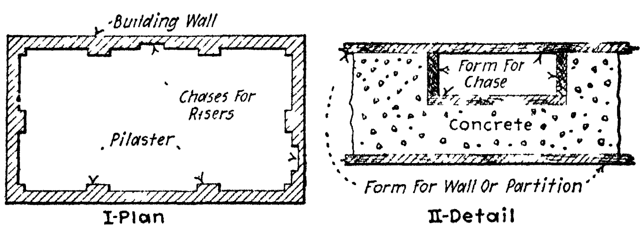



Fig. 334.—Showing method of forming chases for conduit risers.

work on a building is finished. To provide a vertical space for these risers architects often provide wire-shafts or pipe-shafts (the plumbing pipes frequently occupy the same shafts). When no such shaft is provided, or if provided but not conveniently located, chases (Fig. 334) are frequently built into

the walls for the conduit risers. It is the wireman's duty to see that chases, shafts, or equivalent conduit ways are provided.

NOTE.—IF SHAFTS OR CHASES HAVE NOT BEEN PROVIDED FOR RISER CONDUITS, VERTICAL HOLES MAY BE CAST IN THE FLOOR SLABS FOR THEM (Fig. 335) as the building construction proceeds. Drilling holes through finished floor slabs is very expensive. Furthermore, in drill-

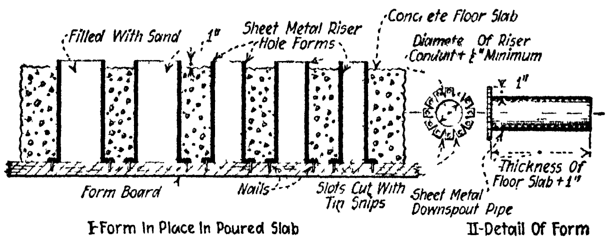



FIG. 335.—Riser-hole forms for conduit.

ing, steel reinforcing may be encountered. This may necessitate the enlargement of the hole or the drilling of another, which will throw the riser from the vertical. Sheet metal downspout pipe may be employed as shown for riser-hole forms.

NOTE.—WHERE CONCRETE STEEL-REINFORCEMENT OR STRUCTURE STEEL FRAMING MUST BE CUT, to permit the running of conduits, either the *electric-arc method* or *the oxyacetylene method of cutting* may be economically employed. The following (from *Popular Mechanics*) describes an improvised electric arc outfit which was used by William Morton of Wheeling, W. Va., for cutting reinforcing steel.

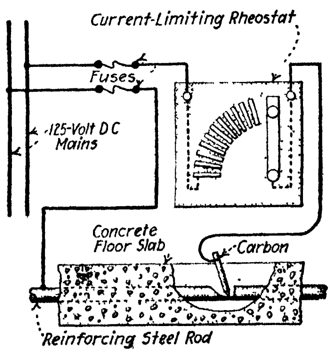



FIG. 336.—Removing a reinforcing-steel obstruction with an electric arc.

*Electric Arc Method.* I used to limit the current a grid starter designed for a 25-hp., direct-current motor, connecting it to the 125 volt direct-current mains, as shown in Fig. 336. I grounded, on the concrete floor, one side of the circuit. To the end of the wire from the starter rheostat, I connected a large electric arc carbon, to serve as the flame electrode. Using a pair of chipping goggles, smoked on the outside to protect my eyes, I applied the carbon electrode to the reinforcing rods, which were burned out after a short time. The current drawn from the mains was about 125 amp. The motor starter was not dangerously overheated.

*The Oxy-acetylene Method* is described by Gordon Fox in *Power Plant Engineering* for March 1, 1918. To avoid excessive *bending* and its attendant high cost and *pulling-in* difficulties an oxy-acetylene torch was purchased. Holes were burned in *beams*, *gusset plates* and other members so as to allow the conduits to pass directly through them. Care was exercised not to materially weaken the members; holes in beams were burned only near the center of the web. The *electric drills* soon became idle; the torch was used instead for burning holes for *U-bolts* and *J-bolts* which were employed for supporting conduits and brackets. A great saving in installation cost resulted. Also, *knockout holes* for conduits were burned in the *steel cabinets*. Later, all cabinets were purchased without knockout holes. The torch was used in the field for burning all of the holes, just where they were required. The torch was also used for heating heavy lugs for *soldering large cables* in them; thereby much less time was required than if a blow torch had been used.

**178. A Method Of Installing Ceiling Outlet Boxes In Hollow-Tile Arches** is illustrated in Figs. 337, 338, 339 and 340.

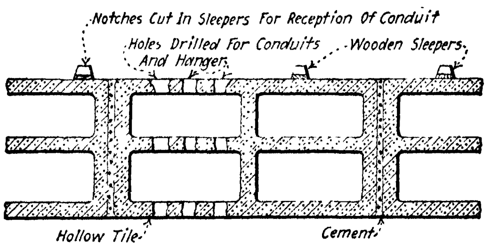



FIG. 337.—Installing a ceiling-fixture outlet box in a hollow-tile floor slab in a building under construction. *First step*, holes made through the tile.

Immediately after the forms and falsework are removed but before the *sleepers* (*screeds*) for the floor are laid, the ceiling-

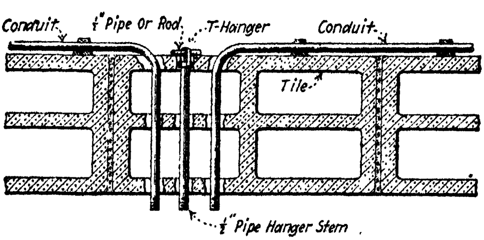



FIG. 338.—*Second step*, conduit bent and fitted into place and T hanger in position.

outlet locations should be determined. Holes should then be punched in the tile (Fig. 337) for the conduit and for a T-

hanger. The holes may be punched with a star drill or with a cold chisel. A T-hanger may be made by screwing a long conduit nipple into a solid pipe ring and then slipping a scrap piece of conduit through the ring. The conduit is then bent to the proper shape to fit the outlet box (Fig. 338). A shallow (¾ in.) outlet box is then fastened to the T-hanger by two

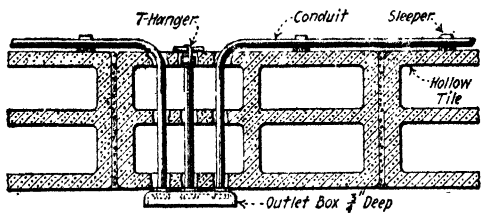



FIG. 339.—*Third step*, shallow outlet box clamped in place with lock nuts.

locknuts and the conduit fastened by locknuts and bushings (Fig. 339) as described in Sec. 170. The openings above the box should then be filled with chips of tile and concrete so as to make a solid layer of concrete and tile above the box (Fig. 340).

NOTE.—A METHOD OF INSTALLING CONDUIT IN TERRA COTTA AND "CONCRETE-JOIST" FLOOR SLABS is shown in Fig. 341. This method is

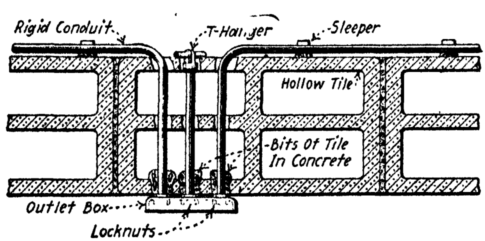



FIG. 340.—*Fourth step*, openings in tile around top of box filled in with concrete and bits of tile.

principally used in construction where the tile is first placed into forms and later concrete is poured over and between the tile. Shallow round outlet boxes (with ears) are placed at the proper locations for all ceiling outlets, the boxes being fastened to the upper side of the form boards as shown in Fig. 341. If a box comes at a place where a tile will be placed, the tile is broken away to make room for the box. With the shallow

boxes, the fixture studs project beyond the face of the boxes; hence holes must be drilled through the form boards to make space for the fixture studs (Fig. 341). After the form boards are removed, the desired cover is placed on the box before plastering is begun.

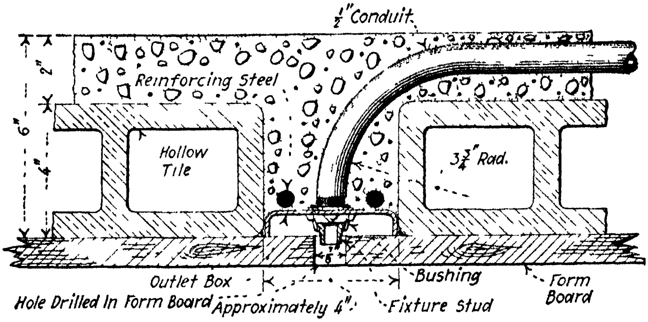



Fig. 341.—Showing method of installing a shallow box in a tile-and-concrete floor slab.

**179. A Method Of Supporting Ceiling-Outlet Boxes In Suspended Ceilings** is shown in Fig. 342. The flat or channel section iron strip to which the box is bolted should be of

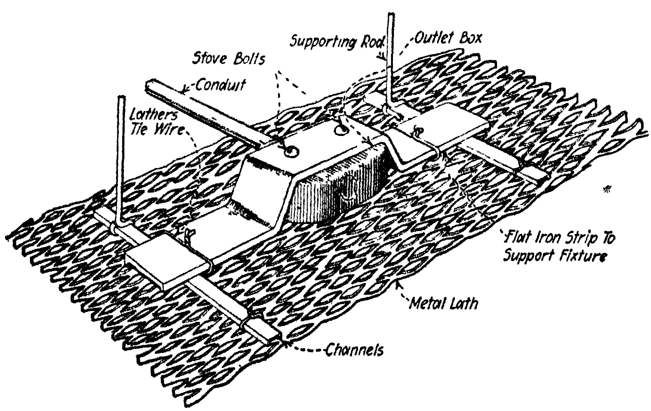



Fig. 342.—Showing method of supporting outlet boxes on suspended ceilings.

sufficient length to span the small channels which form the framework of the ceiling.

Note.—It Often Pays To Assemble On The Floor Conduit Runs Which Will Be Placed On Suspended Ceilings Before The Ceiling Is Hung. This is particularly advisable for such long runs as those which serve corridors and the like. The assembling can be done much

more readily on the floor than in the small space above the ceiling. If the wiremen cannot remain on the job to place the conduit run as the lathers hang the ceiling, they can sometimes effect a deal whereby the lathers themselves will raise the assembled run to approximately its proper position.

**180. A Method Of Installing Switch Boxes In Unfinished Fireproof Walls Or Partitions** is illustrated in Figs. 343, 344, 345 and 346. When the ceiling outlet box for the fixture which is to be controlled by a certain switch is being installed, a piece of conduit is run horizontally in the ceiling slab from the box to the *location* of the wall or partition which is to contain the switch. The end of the conduit (being threaded) is bent downward so as to project from the floor slab (Fig. 343). After the floors are completed, a piece of conduit of the proper length and threaded at both ends is coupled to the

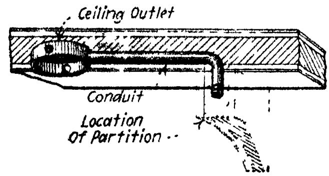



FIG. 343.—Horizontal run of conduit from ceiling outlet turned down out of floor slab toward the switch-box location.

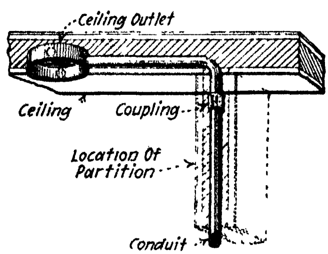



FIG. 344.—A piece of conduit cut to the proper length and threaded on both ends is coupled to the short conduit which projects from floor slab.

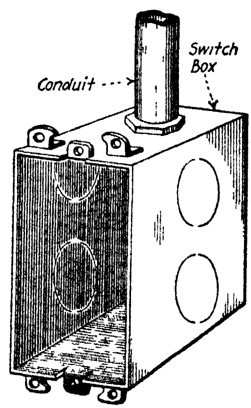



FIG. 345.—The switch box is secured to the conduit with locknuts and bushing.

projecting end of the conduit previously installed (Fig. 344). A switch box is then fastened (as directed in Sec. 170) to the lower end of this conduit as shown in Fig. 345. The end of the conduit is then plugged (Sec. 61).

NOTE.—IT IS SOMETIMES NECESSARY TO SUPPORT SWITCH BOXES AND SIDE OUTLET BOXES TEMPORARILY until the wall or partition is built. One way of thus supporting the switch box is shown in Fig. 346. Another method, which has been used by the L. K. Comstock Co., is shown in Fig. 347.

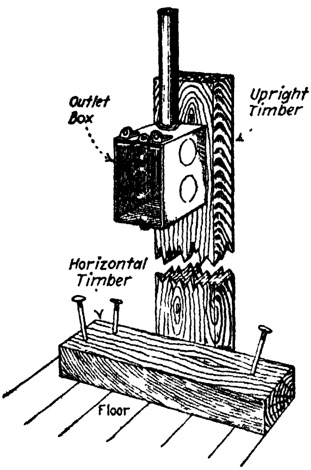



FIG. 346.—Temporary switch box support to prevent an accidental change of the outlet box location.

NOTE.—TO RELOCATE A BRACKET-OUTLET CONDUIT IN A PARTITION, as sometimes is necessary when the conduit end, which is dropped from the floor above to feed a bracket outlet, is incorrectly placed (as shown in Fig. 348-*I*) proceed as follows: The error may be remedied by chipping away a small section of the concrete (or tile) floor above (Fig. 348-*II*) and extending the bend in the conduit so that it will center properly in the partition. This operation will, of course, shorten the conduit end which projects downward. To compensate for this, an extension is added to the conduit end by means of a coupling, as in *II*. Be careful, however, not to chip away too much concrete.

NOTE.—THE INSTALLING OF AN OUTLET BOX IN AN EXISTING TILE PARTITION can be effected as shown in Fig. 349. It will probably be necessary to destroy a number of pieces of tile in order to locate the box

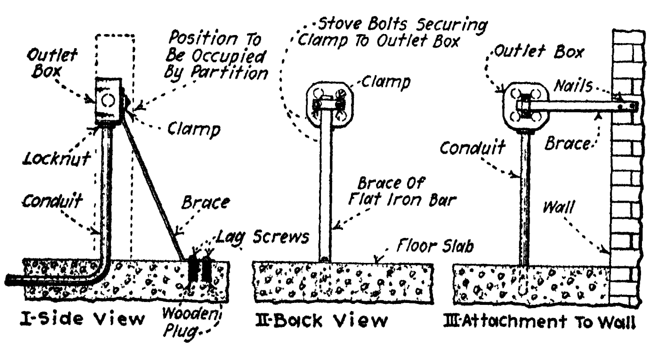



**FIG. 347.—Flat iron brace used to support side-outlet boxes during construction. Brace is fastened to box back with a clamp. The braces and clamps may be used over and over again.**

**at the point where it should be installed. After the conduit and box are in position, the cavities from which the tile was removed can be filled up with bricks or pieces thereof or pieces of tile. A vertical run can be**

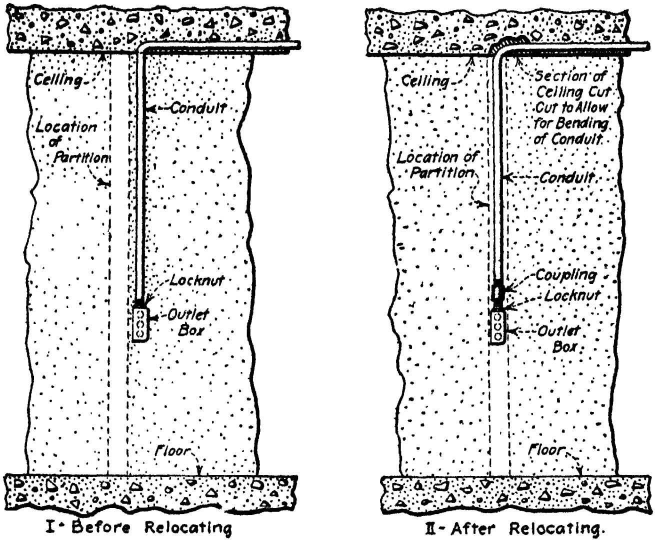



FIG. 348.—Relocating bracket-outlet conduit in partition.

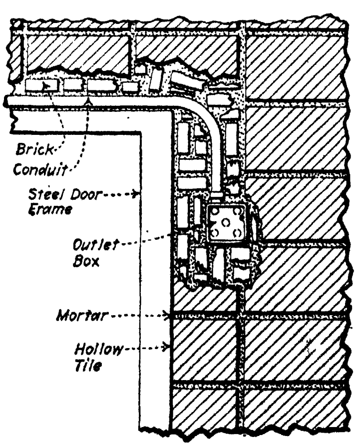



FIG. 349.—Arranging conduit outlets in existing tile partitions.

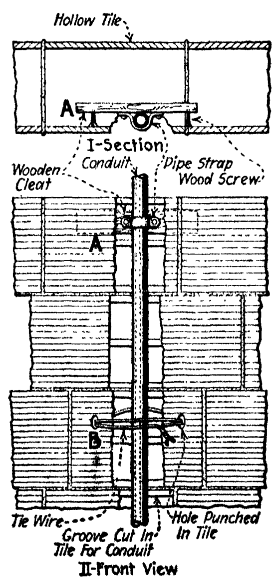



FIG. 350.—Supporting a vertical conduit run in a hollow tile surface.

supported with either a wooden cleat and pipe strap (*A*, Fig. 350) or with a tie wire as at *B*. If the conduit must set rather far back, wood screws can be set in the cleat to hold it back as at *I*. To install the cleat: Place the cleat in the notch in the tile, then fasten the conduit to the cleat with a pipe strap and wood screws.

**181. Methods Of Supporting Outlet Boxes On Tile-Covered Steel** are shown in Figs. 351, 352, 353 and 354. Difficulty is often encountered in holding outlet boxes rigidly in place on steel columns while the tile-setters "fireproof" a column with

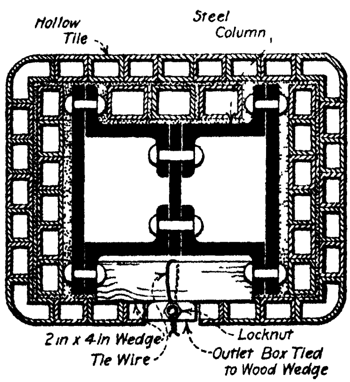



FIG. 351.—Transverse section of supporting block wedged between column flanges.

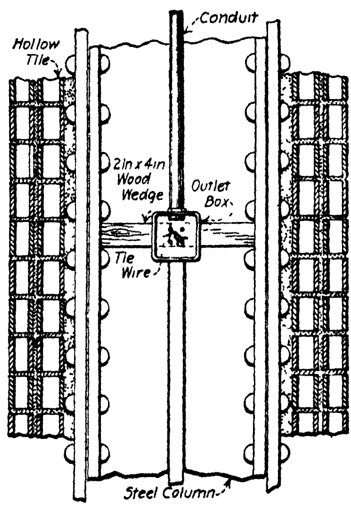



FIG. 352.—Elevation of supporting block wedged between column flanges.

tile. The method of Figs. 351 and 352 is for supporting boxes between the flanges of steel columns whereas Figs. 353 and 354 illustrate a method of supporting boxes on the exteriors of flanges. In Fig. 351 the wedge should be cut to such a length that it will drive tightly between the column flanges, thus providing a secure job. In Fig. 353, the box is nailed to a block which has been secured to the column flange with a tie wire. The conduit (Fig. 354) is also secured with a tie wire. Faces of outlet boxes should set flush with the face of the tile, or preferably slightly beyond the tile face to allow for the plaster.

**182. A Method Of Supporting Ceiling Outlet Boxes In Frame Buildings** is shown in Fig. 355. In many cases the conduits running to an outlet box can be bent over the floor

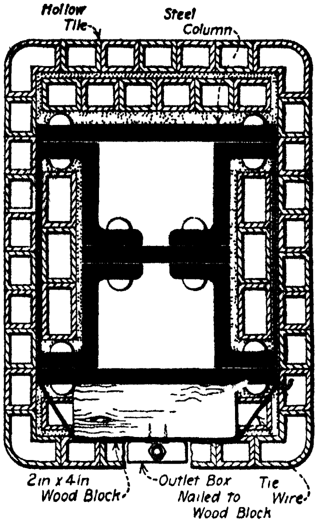



FIG. 353.—Plan of supporting block held to column with wire.

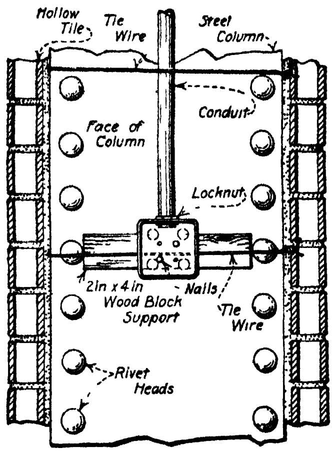



FIG. 354.—Elevation of supporting block held to column with wire.

timbers in such a way as to support the box satisfactorily without any special provisions being made for sustaining it. But in cases where, because of the fixture being exceptionally

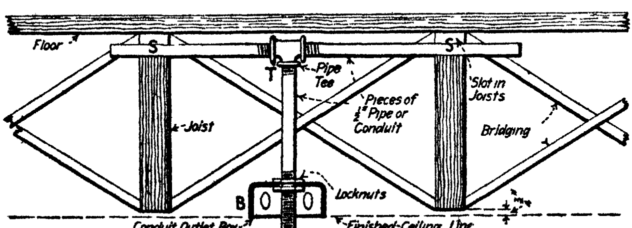



FIG. 355.—Method of supporting an electrolier outlet box on pipe fittings.

heavy or because adequate support is not otherwise feasible, an outlet box can be suspended as shown in Fig. 355. The lengths of pipe, *S* and *S*, are screwed into the malleable-iron pipe fitting *T*. Also into the side outlet of this fitting is

screwed the pipe or conduit to which the outlet box is supported with locknuts. The bottom edge of the box should,

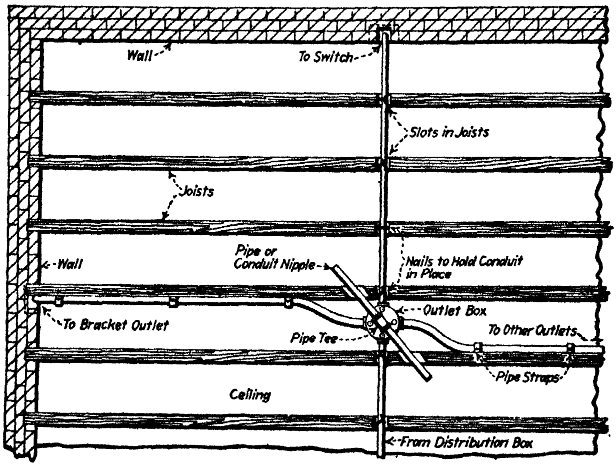



FIG. 356.—Arrangement of ceiling outlet in frame building.

as shown, lie ¾ in. below the edges of the joists to provide for lath and plaster. Various forms of special hangers are on the

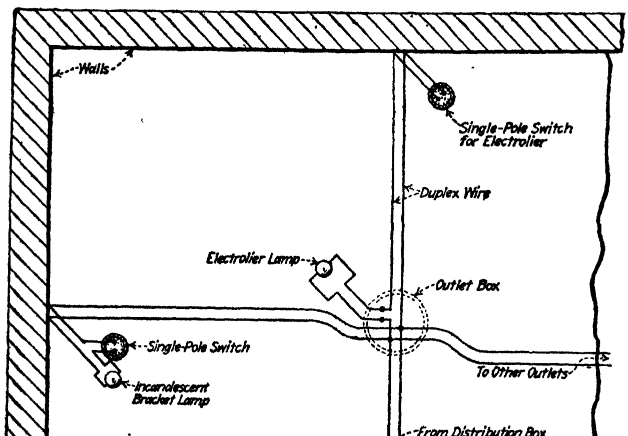



FIG. 357.—Wiring diagram for conduit outlet box.

market which can be used instead of the improvised hanger shown in Fig. 355.

NOTE.—THE SUPPORT OF THE CONDUIT IN FRAME BUILDINGS may be as shown in Fig. 356. Where the conduit run is parallel with the direction of the joists, the conduit is held to them with pipe straps which are fastened to the joists with nails. Where the conduit crosses joists, it lies in grooves (see Sec. 183) cut in the upper edges of the timbers. In cutting these grooves, two parallel saw cuts are made and the block of wood between them is then cut away by using a wood chisel. To hold the conduit down in the slots either pipe hooks or nails bent over the conduit, as shown in the illustration, may be applied. The wiring arrangement for this room is shown in Fig. 357.

**183. When Installing Conduit In Wooden Joist Floor Construction,** great care must be exercised. Cutting slots in

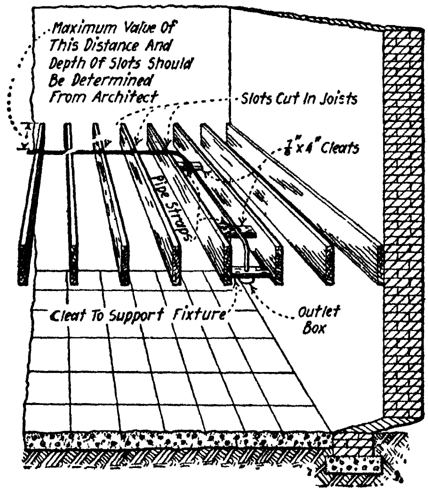



FIG. 358.—Showing methods of supporting rigid conduit in slots in joists and on cleats between joists.

joists, as suggested in the preceding note, greatly weakens the joists at the point where the slots are cut. Hence, architects and owners often forbid the slotting of joists at points other than near the supports of the joists where the full strength of the unslotted joists is never needed. In fact, a conscientious electrician will not attempt any work which may weaken the building. Hence, the distance from the point of joist-support (wall or girder) to the slot should be kept as small as possible; often 2 ft. is specified as a limit (see Fig. 358). The cutting of slots in joists may be avoided by passing the conduit through holes which are drilled through the joists at

their centers (Figs. 359 and 360). These holes may be drilled just about as quickly as the joists can be slotted; the

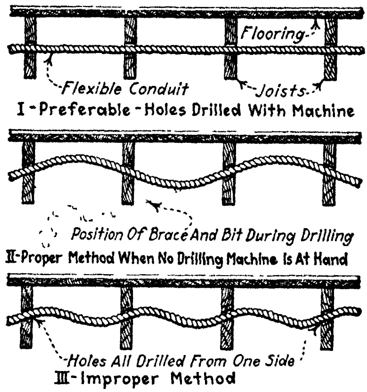



FIG. 359.—Methods of drilling holes in joists for flexible conduit.

holes weaken the joists very much less than do slots (see Table 184). When joists are drilled, it is customary to employ flexible conduit as shown in Fig. 359.

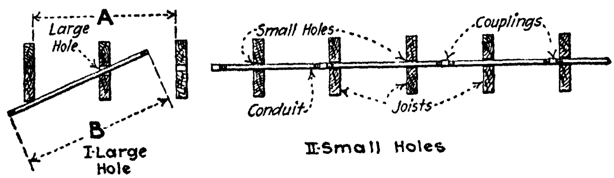



FIG. 360.—Showing how rigid conduit can, when it must, be run through holes in centers of joists.

**184. Table Showing How Much Joists Are Weakened By Slots and Holes.**—The values given are in *per cent.*

| Depth of slot or diam. of hole, in. | Slot at top or bottom of joist | | | | | | Hole at center of joist | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Depth of joist, inches | | | | | | Depth of joist, inches | | | | | |
| | 8 | 10 | 12 | 14 | 16 | 18 | 8 | 10 | 12 | 14 | 16 | 18 |
| 1 | 23.4 | 19.0 | 16.0 | 13.7 | 12.0 | 10.8 | 0.20 | 0.10 | 0.06 | 0.04 | 0.02 | 0.02 |
| 1½ | 34.2 | 28.0 | 23.4 | 20.5 | 17.8 | 16.0 | 0.67 | 0.34 | 0.20 | 0.12 | 0.08 | 0.06 |
| 2 | 43.8 | 35.6 | 30.5 | 26.6 | 23.4 | 21.1 | 1.57 | 0.80 | 0.46 | 0.29 | 0.20 | 0.14 |
| 2½ | 53.0 | 43.9 | 37.5 | 32.2 | 28.6 | 26.0 | 3.05 | 1.56 | 0.91 | 0.57 | 0.38 | 0.27 |

NOTE.—WHEN SPECIFIED THAT RIGID CONDUIT SHALL BE RUN THROUGH DRILLED HOLES IN THE CENTERS OF JOISTS, the installation of the conduit becomes difficult. Care must be taken that the holes are drilled so as to "line up" quite accurately or trouble may be experienced when the conduit is being worked into them. Furthermore, the conduit must be cut into relatively short pieces in order to "enter" into the holes. If the holes are drilled approximately the same size as the conduit, the maximum length that can be "entered" is that between the faces of adjacent joists. By drilling one large hole at the end of a straight run which is to extend crosswise the joists, however, lengths equal to almost twice the joist spacing can be entered, as shown in Fig. 360.

EXAMPLE.—In a certain job, ½-in. conduit is to be run through 2 by 12-in. joists which are spaced 16 in. on centers. Since ½-in. conduit has an external diameter of 0.84 in., it will require 1-in. holes provided

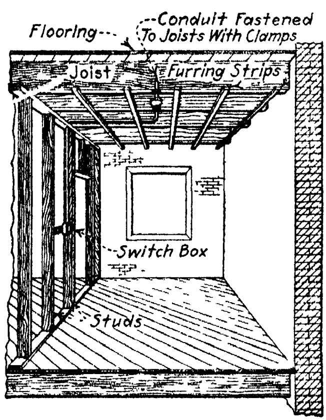



FIG. 361.—Showing method of supporting conduit in a building where furring strips are employed.

that no hole is drilled more than $\frac{1}{16}$ in. "out of line." It would be better to drill 1¼-in. holes and thus provide more clearance in the holes. With 1-in. or 1¼-in. holes, the longest piece that can be worked into the holes would be about (16 − 2 =) 14 in. long. If, however, a 2-in. hole were drilled at one end of the run, pieces about (32 − 2 =) 30 in. long could be worked into the holes. Thus, less than half as many joints would have to be made up with the one 2-in. hole as would be required if all holes were drilled only 1¼ in. By Table 184, a 2-in. hole in a 12-in. joist weakens it less than ½ per cent. Hence, no harm could result directly from drilling the holes in the center of the joists.

**185. Methods Of Supporting Ceiling-Outlet Boxes In Framed Buildings** are shown in Figs. 358 and 361. Although wooden cleats are most often used for this purpose, various

manufactured devices are also being used. Since they require so little time to install, these devices usually make for less

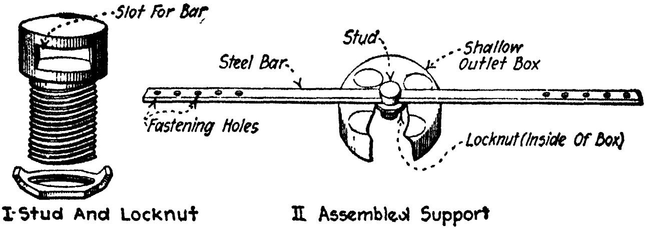



FIG. 362.—*Austin* adjustable outlet-box support.

cost on a job than using wooden cleats. Furthermore, the manufactured devices generally provide a stronger support

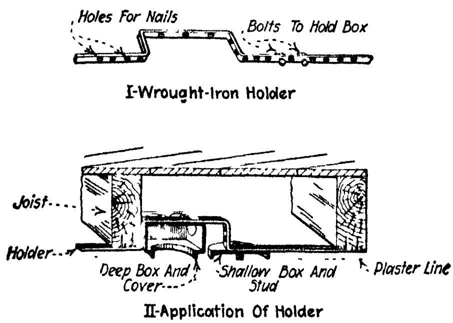



FIG. 363.—Wrought-iron box holder.

for the fixtures which will ultimately be hung from the outlet boxes. Such devices are shown in Figs. 362, 363, and 364.

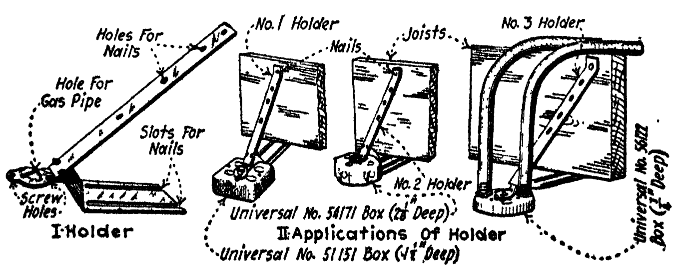



FIG. 364.—Outlet box holders and their application.

**186. The Installation Of Conduit In Buildings Made Up Of "Steel Lumber"** or structural pressed steel is illustrated in

Figs. 365, 366, and 367. When the pressed steel I-joists are used in a floor construction, they are usually covered with metal lath onto which concrete is then poured to form the floor.

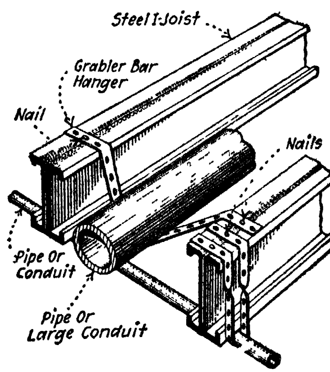



FIG. 365.—Conduits installed in steel "lumber" floor.

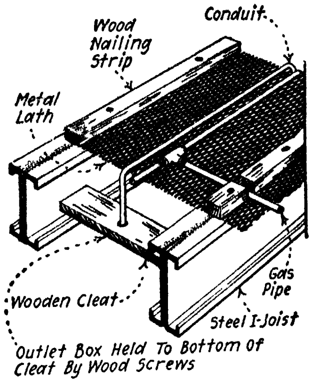



FIG. 366.—Ceiling outlet in steel "lumber" floor slab where wooden floor is to be used.

When a wood-covered floor is desired, sleepers or screeds are laid into the concrete to provide a ground to which the wood flooring can be nailed. The conduit may be laid directly onto

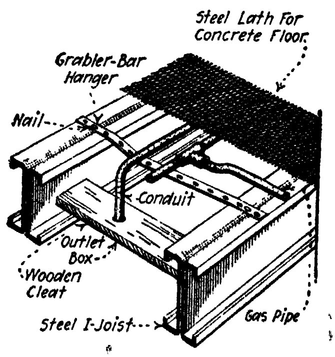



FIG. 367.—Ceiling outlet in "lumber" steel floor slab where concrete floor is to be used.

the metal-lath forms as shown in Fig. 366 or it may be supported from the joists by Grabler's extension bars as shown in Figs. 365 and 367. The extension bar may be fastened to the I-joists by driving nails between the two halves of the I-joists.

Outlet boxes may be supported by wooden cleats placed across between flanges of adjacent joists as shown in Figs. 366 and 367.

**187. A Method Of Fastening Outlet Boxes At Door Bucks In Terra Cotta Partitions** is shown in Figs. 368 and 369. Frequently, side-outlet boxes are to be located near some opening in the partition, such as that for a door or window. Before

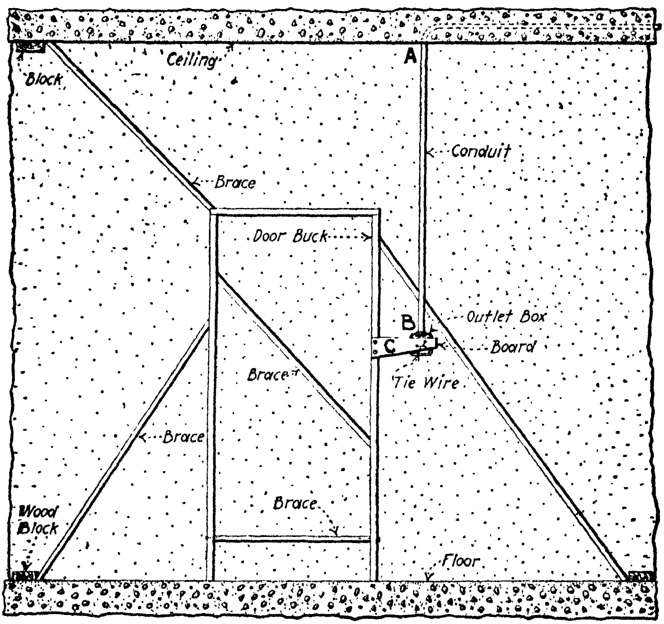



FIG. 368.—Method of supporting an outlet box from a door buck.

the placing of the terra cotta, a "buck" or form is arranged, as shown in the illustration, around which the terra cotta blocks are laid. The outlet boxes are usually temporarily supported on bars, *C*, or strips (Figs. 368 and 369) which are nailed to the side of the buck. After the partition has been completed, the door buck remains in place, but the bar which temporarily supported the outlet box is removed. The outlet box may be held to the bar support, *C*, with either nails or with a tie wire as suggested in Fig. 368. The front-face edge of the outlet box should lie in the same plane with the face edge of the door "buck," if the door buck is made of the thick-

ness of the finished partition (see Fig. 370). The height of the outlet box from the floor and its distance horizontally from the

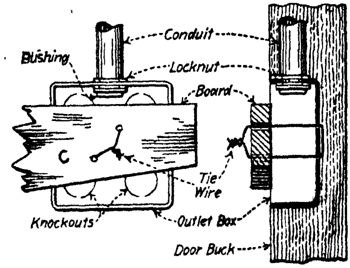



FIG. 369.—Detail showing support of outlet box on board at door buck.

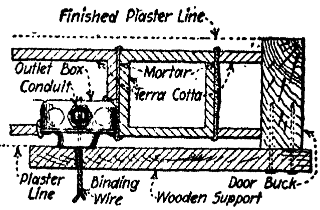



FIG. 370.—Wooden support for switch boxes in terra-cotta partitions.

door-buck form, varies for different installations and may be determined by consulting the plans and specifications for the job in question. After the terra-cotta partition has been completed, the conduit length, *AB* (Fig. 368) is, of course, imbedded within the partition.

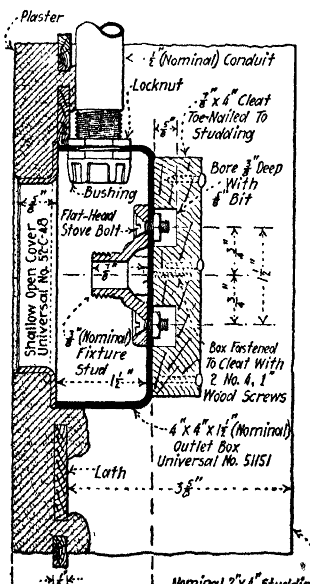



FIG. 371.—Showing method of fastening wall-bracket outlet box in a stud partition.

NOTE.—A METHOD OF SUPPORTING OUTLET BOXES IN STUD PARTITIONS is shown in Fig. 371. Although the box shown is fitted with a fixture stud, the method applies equally well to the support of switch outlet boxes. A piece of 7/8 by 4-in. stock

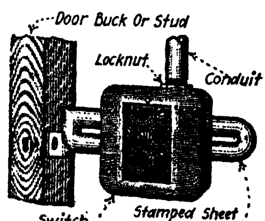



FIG. 372.—Showing application of the stamped-steel switch box holder.

is cut to the proper length to fit between adjacent studs. The outlet box is fastened to this cleat with screws or nails. The cleat is then nailed

to the studs at the proper place so that the outer edges of the box (or the outer edge of cover if one is to be used) will come flush with the outer face of the finished plaster.

NOTE.—PRESSED-STEEL BOX SUPPORTS (Fig. 372) may also be used for supporting outlet boxes at door bucks or between studs. These supports are somewhat similar to the devices described in Sec. 185 and have the same advantages.

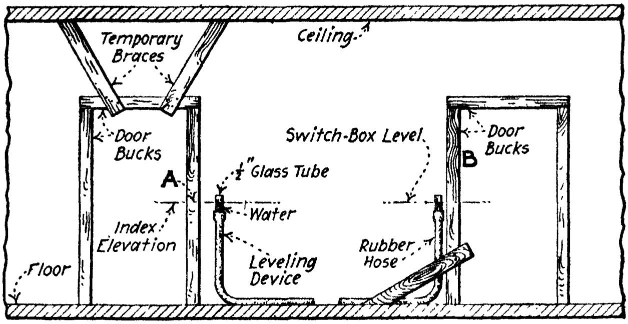



FIG. 373.—Hydraulic conduit-box levelling device being used for locating all switch boxes at the same elevation at door bucks.

**188. A Hydraulic Method Of Accurately Locating A Number Of Switch Boxes All At The Same Elevation,** when the floors and ceilings are too uneven to measure from, is illustrated in Fig. 373. This arrangement permits of very rapid work where many side-outlet boxes, which will ultimately lie in wooden panels or similar locations, have to be roughed in accurately. Fig. 374 shows this hydraulic level.

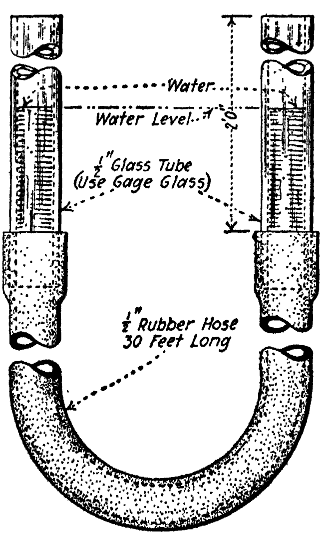



FIG. 374.—Hydraulic conduit-box levelling device.

EXPLANATION.—Assume that a number of switch boxes have to be installed, each at the side of a door buck, and all exactly at the same elevation. Proceed as follows: The wireman first determines the correct height for the switch at one door buck, and indicates on the buck with a pencil mark this index elevation; *A*, Fig. 373. The two glass tubes in

the ends of the rubber hose are then brought together as indicated in Fig. 374. Water is poured into the hose until the level of the water in the tubes is at the height of the mark, *A*, on the index door buck. A piece of tape is then wrapped around each of the tubes indicating this correct water level. One glass tube is now held at the index door buck which has the switch elevation marked on it, so that the tape mark on the tube is on a level with the index mark on the door buck. The water may now either be above or below this tape mark. The other end of the tube is taken to an adjacent door buck (*B*, Fig. 373) where a switch is to be located. The end of the tube at *B* which contains the glass is raised or lowered until the water level in the tube at *B* just reaches the tape mark on the tube. A mark is made on the door buck at *B* at the elevation of this tape mark. The switch should be installed at the elevation of this mark.

**189. Another Method Of Supporting Switch-Outlet Boxes In Terra Cotta Partitions** is shown in Fig. 375. This method is particularly adaptable to installations where flexible conduit is employed. A flat-iron bracket, *F*, is fastened by screws, *B*, to the door buck. Another flat-iron bracket, *C*, is fastened to a 4-in. square outlet box with two bolts *A*, and is then placed at the proper distance from the door buck and bolted

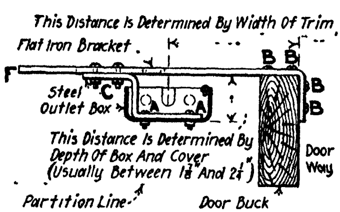



FIG. 375.—Showing bracket used for supporting switch outlet boxes for hollow-tile partition construction.

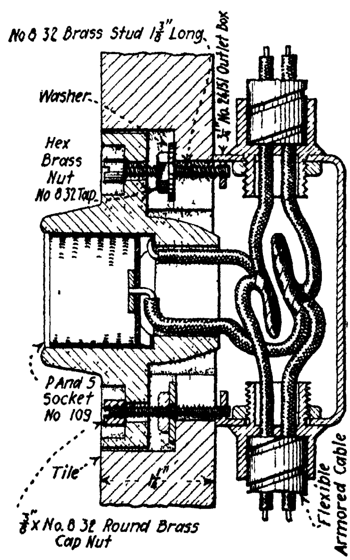



FIG. 376.—Sectional detail on line *AA* of Fig. 377 showing socket, box and conduit in position on tile.

to *F*. After the partition is built the screws *A* and *B* are removed, leaving the box nicely set in the partition. The brackets may be used repeatedly on different jobs.

**190. A Method Of Installing Light Outlets On Mosaic-Tile Building Fronts** (Figs. 376 and 377) was developed by the

department of Gas and Electricity, of Chicago, under the direction of its chief electrical inspector, V. H. Tousley. With this, the difficulties which are ordinarily encountered

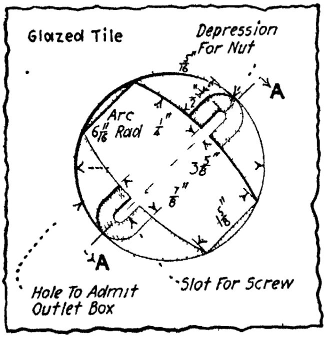



FIG. 377.—Detail of oblong hole in mosaic tile.

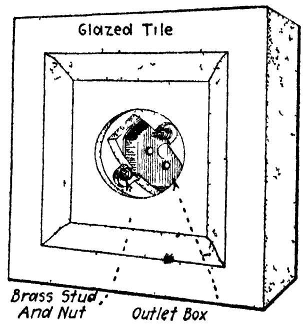



FIG. 378.—Front of tile showing outlet box in position.

in such work in properly supporting sockets and outlet boxes are obviated. If flexible armored cable is used, the installation may be made from the outside after the tile (Figs. 378, 379 and 380) has been set. If rigid conduit is employed, it may

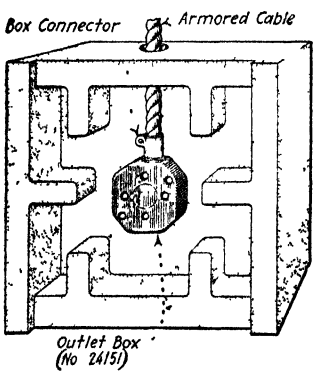



FIG. 379.—Rear view of tile showing outlet box and armored cable in position.

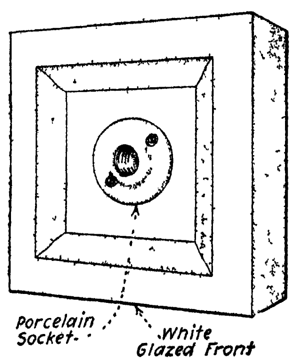



FIG. 380.—Porcelain socket in position over outlet box.

be necessary to place the conduit in position as the tiles are being set; the conductors and outlet boxes may be installed later.

EXPLANATION.—The electrical equipment which is used is all standard. The weatherproof porcelain socket (Fig. 376) which is used has an

extended cover, such as is commonly used for ceiling lights. The screw holes in this socket fit the standard 4-in. outlet box. The terra cotta tile can be furnished by tile manufacturers. The brass extension screws are made by the Corbin Screw Co., of North Wells street, Chicago. These headless screws are provided with a slotted cap nut and another ordinary nut. The screw is first fastened to the outlet box and the nut tightened against the tile. Thus the box is held independent of the socket. After the socket is in place the cap nut is installed. The method of installation is simple: The outlet box, with one piece of the connecting cable, is inserted through the oblong slot (Fig. 377) in the tile. The box is then

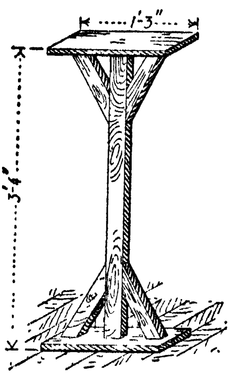



FIG. 381.—Pedestal for supporting cabinet boxes while marking holes for drilling.

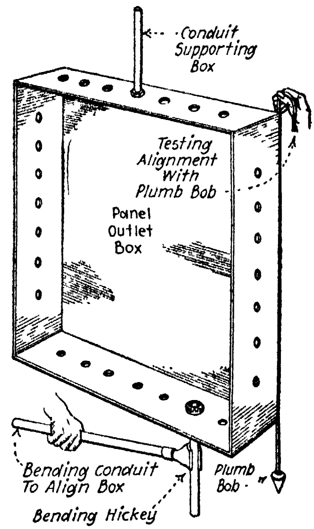



FIG. 382.—Showing method of aligning a panel box.

turned face out and the necessary conduit and wiring connections are made. After the socket has been fastened in place with the screws, it may then be sealed in with cement to make a thoroughly weatherproof job.

**191. Cabinets In Concealed-Conduit Jobs** are generally set "flush"; that is, the box for the cabinet is so set that it does not extend outward from the wall surface in which the cabinet is placed. The methods of placing these boxes are many but, essentially, they are quite similar to those employed for small wall-outlet boxes. If the box is to be erected before the installation of the wall or partition in which it is to be mounted, the box may be supported on a temporary framework until the wall or partition is built up to it (Fig. 381). Such a

framework will more than pay for itself where several boxes are to be located at the same elevation. Frequently, however, the cabinet box is supported temporarily only by the conduit which feeds into and out of it. Various methods of supporting and erecting the boxes generally suggest themselves when the job is tackled. The principal points on which special attention are required are to see that the boxes are placed with their front edges in exactly the plane of the finished wall and to see that the boxes are set plumb (Fig. 382). If the

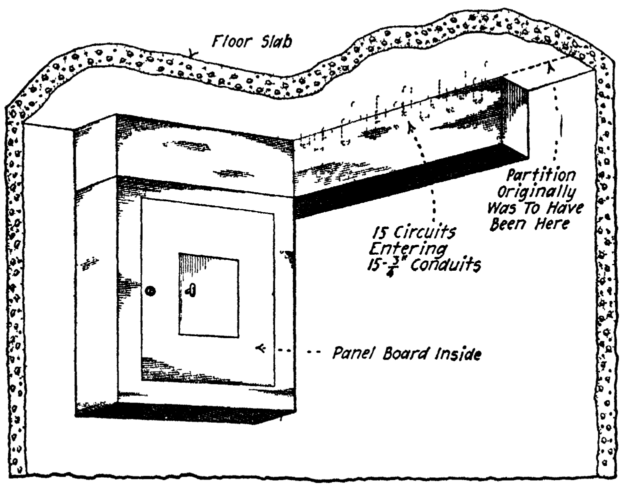



Fig. 383.—Showing how a cabinet was connected in a building where the cabinet location was changed after the conduit was placed.

boxes are supported by the conduit, the correct position and alignment can be secured by bending the conduit. If a temporary support is used it must be accurately placed and aligned.

Note.—Alignment Of Cabinet Boxes Is Generally Effected By Plumbing.—The method is illustrated in Fig. 382. The location of of the box may first be laid out on the floor. The plumb bob then serves to indicate whether the box is in the proper place as well as whether it is plumb or not.

Note.—The Correction Of A Case Where The Location Of A Partition, Which Was To Contain A Flush Cabinet, Was Changed after conduit ends had been left projecting downward from the floor slab above, is shown in Fig. 383. The cabinet also had to be moved to a

different partition. The connection, as it was made (Fig. 383), consisted of a spacious pull box to the cabinet which was set on the surface instead of flush.

**192. The Support And Alignment Of Steel Cabinets, In Steel-Fireproof Buildings,** prior to the installation of the partitions in which the cabinets will ultimately set, is sometimes a problem. Where a cabinet is to be located in a special

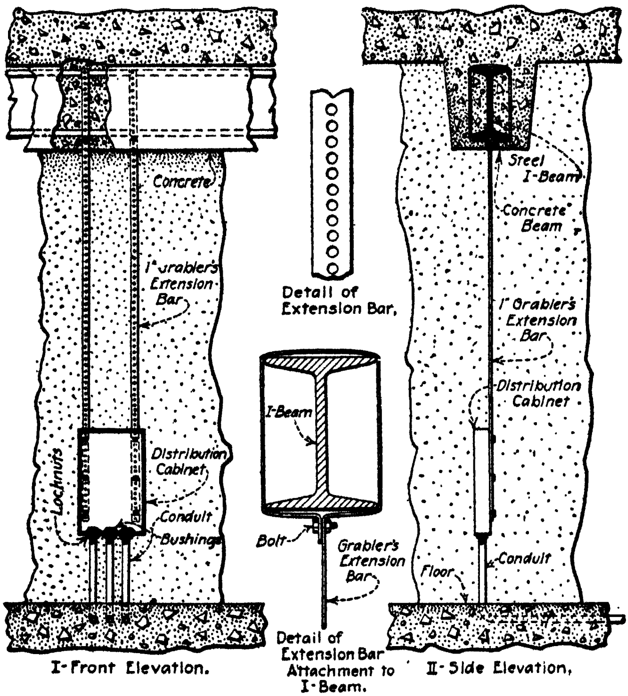



FIG. 384.—Supporting steel cabinet with Grabler's extension bar.

compartment—usually near an elevator or light shaft—the cabinet can often be installed directly under a beam in the floor above. When such is the case, the cabinet can be supported by strapping two lengths of "Grabler's" extension bar around the beam above (see Fig. 384) and bolting the back of the cabinet to the bars. When an extra large cabinet is to be installed, it may be supported by attaching to two

angle-iron hangers which are fastened to the beam above with hook bolts (see Fig. 385 and details of Fig. 386).

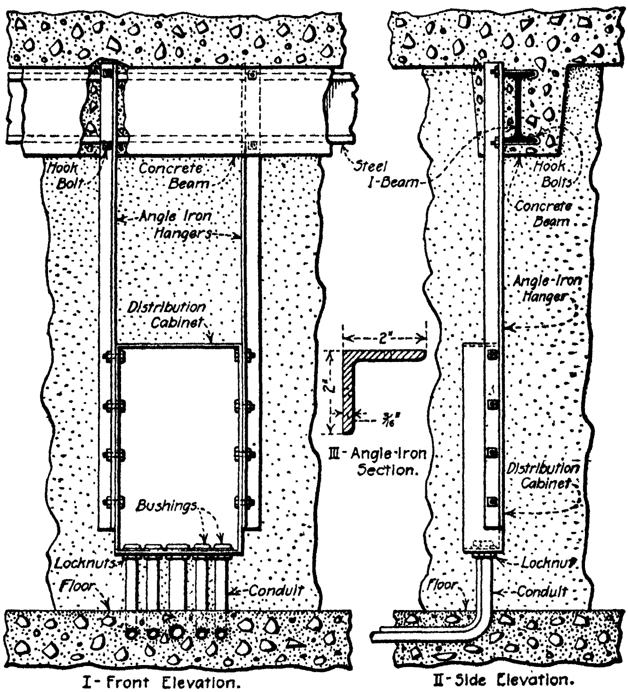



FIG. 385.—Supporting distribution cabinet with steel angles.

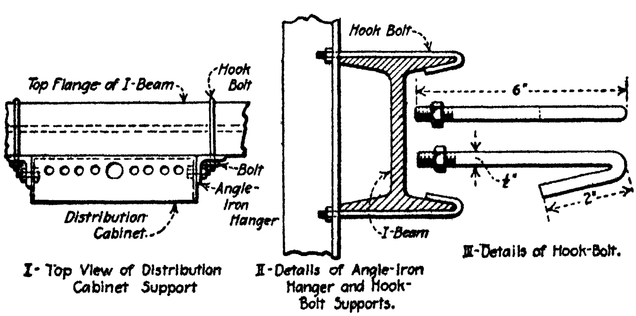



FIG. 386.—Method of supporting distribution cabinet with hook bolts.

**193. The Alignment Of Switch- And Receptacle-Outlet Boxes** should be such that all edges of the boxes are either

horizontal or vertical and that the front face of the box lies parallel to and not more than, say, ⅛ in. back of the finished wall surface (after plastering). If, then, the box cover is fastened to the box which has been accurately set, it will be in the proper position to hold the switch or receptacle and will permit the flush plate to take a horizontal or vertical position. The front edges of the box—or, of the box cover, if such is used—should finally after the plaster is on, lie flush with the finished wall surface or not to exceed ¼ in. back of the finished wall surface. Frequently, however, the conduit or boxes are displaced by other workmen after they have been carefully located by the wireman. If such an accident is not noticed by the wireman until after the box has been surrounded by concrete, tile, or other rigid material, he cannot usually move

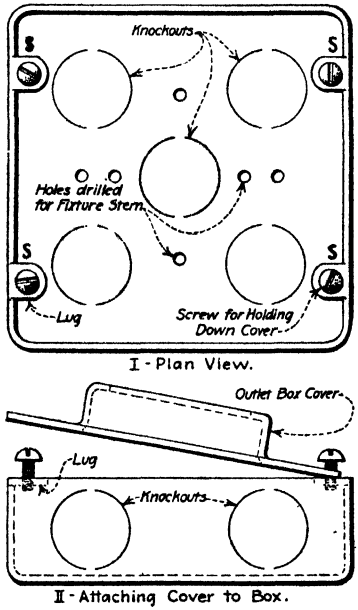



FIG. 387.—Attaching cover plate to outlet box.

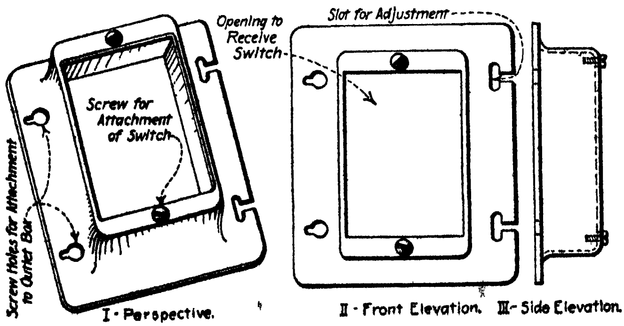



FIG. 388.—Conduit-outlet-box cover.

the box. He must, if possible, leave the box as it is and "doctor it up." This he may do by so attaching the outlet-

box cover that the cover will lie practically flush and in alignment, although the box itself is not in alignment.

Example.—A typical square conduit box is shown in Fig. 387-*I*. The type of cover commonly used for switches and receptacles in square boxes is shown in Fig. 388. After loosening the screws, *S* (Fig. 387), somewhat, the cover is fastened to the box by slipping it on as shown in Fig. 387-*II*. If the box is only slightly out of alignment in the plane of the wall, correction may be made by "skewing" the cover as shown in Fig. 389. Alignment at right angles to the plane of the wall may be made by using a straightedge across the ground strips as shown in Fig. 390, or, if but one ground strip is available, as shown in Fig. 391. See Sec. 194 for methods of aligning box covers.

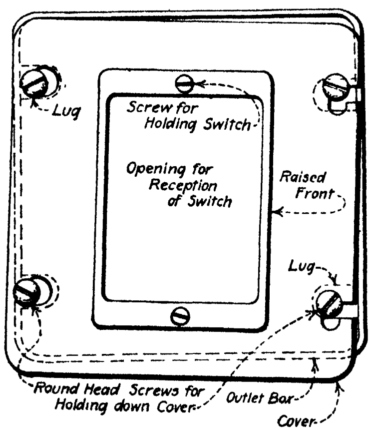



Fig. 389.—Adjustable feature of cover of Fig. 388.

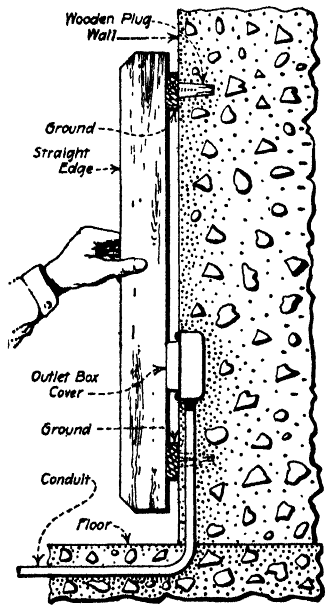



Fig. 390.—Straightedge used to line up box-cover fronts with plaster grounds.

**194. Methods Of Aligning Outlet-Box Covers,** when alignment cannot be secured as explained in the preceding example, are given below. Sometimes a box stands so far out of alignment in the plane of the wall that the slots in the cover afford insufficient adjustment for placing the cover properly. In such cases, greater adjustment may be secured by cutting away a portion of the metal at the slots as shown

by the shaded area in Fig. 392-*I*. The metal may be cut along lines *AB* and *BC* with a cold chisel. Or, it may be cut along *BC* with a hack saw and the piece then broken off along *AB* by bending the piece back and forth with a pair of pliers. Box covers which have thus been cut away must be secured with washers placed under the holding-screw heads (Fig. 392-*II* and *III*)

**195. Covers For Boxes Which Are Materially Out Of Alignment At Right Angles To The Plane Of The Wall May Be Aligned** by the method of Fig. 393 or 394. A metal, stone, or brick wedge would be preferable to the wood wedge shown in Fig. 394 because of the inflammability of the wood. Some manufacturers supply a number of thin spacer washers, having a total thickness of about $3/16$ in., with each flush

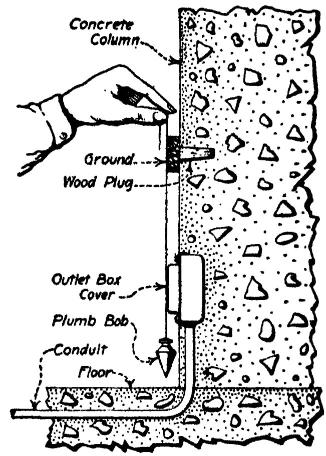



FIG. 391.—Plumb bob and cord used for lining up front of box cover with plaster ground.

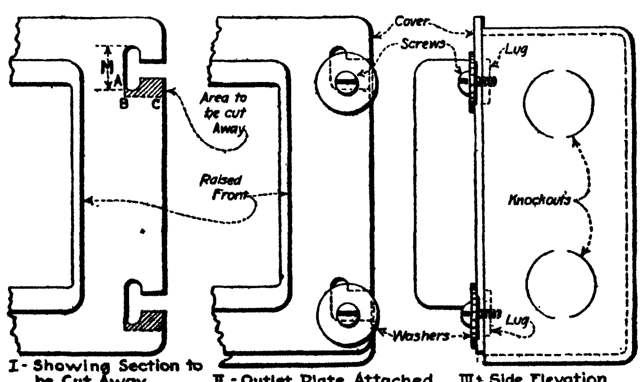



FIG. 392.—Cutting away section of cover plate to facilitate alignment.

device which they sell. These washers may be used (Fig. 395) in cases where an outlet box is not greatly out of alignment. See also Sec. 196 on the use of spacer washers.

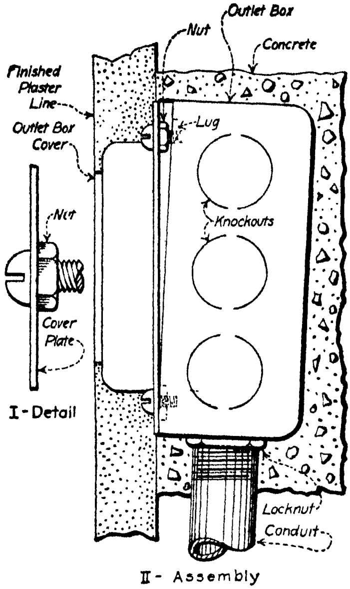



Fig. 393.—Aligning front face of box cover by using screw and nut.

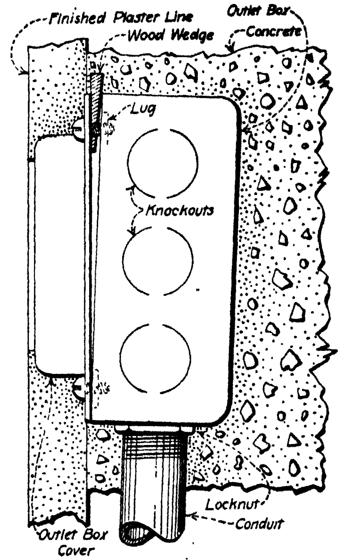



Fig. 394.—Aligning front face of box cover by using a wedge.

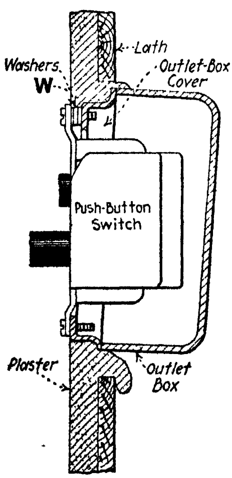



**Fig. 395.—Showing how a flush device (switch or receptacle) may be aligned on a tilted outlet box with washers, *W*, under the yoke.**

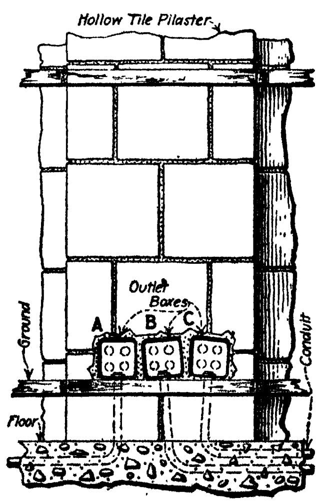



**Fig. 396.—Base-receptacle boxes out of alignment.**

NOTE.—THE ALIGNMENT OF THE COVERS FOR SEVERAL ADJACENT, OR A "GANG" OF, OUTLET BOXES (Fig. 396) is especially important because a slight amount of misalignment is, in such a case, very noticeable. After the cover for the first box (*A*, Fig. 396) has been aligned as described in the preceding sections, a specially made straightedge (Fig. 397) may

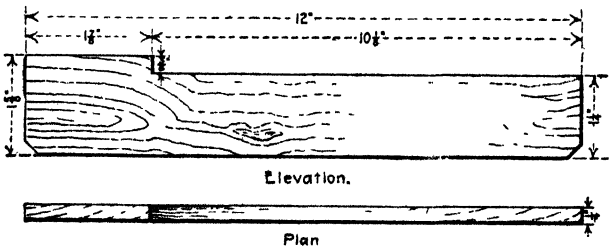



FIG. 397.—Details of straightedge.

be used to advantage for aligning the remaining boxes as depicted in Fig. 398.

NOTE.—TO FASTEN A COVER ON A CONDUIT BOX WITH A STOVE BOLT WHEN THE THREADS IN THE BOX LUGS HAVE BEEN STRIPPED, proceed (Fig. 399) as follows: Ream out the hole with a file tang so that the bolt will pass through it readily. Place the nut right under the hole

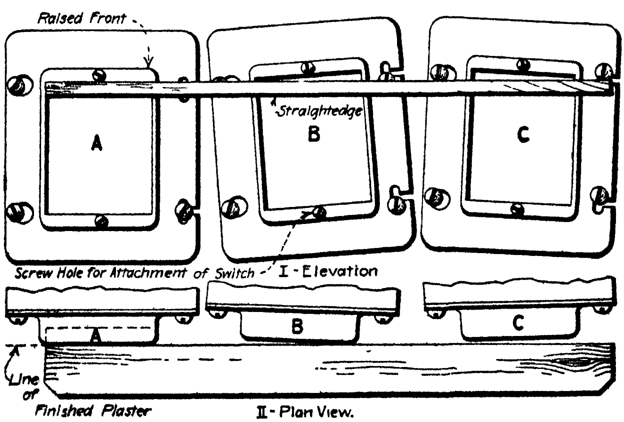



FIG. 398.—Straightedge used for alignment of box-cover fronts.

in the box lug. Place a little putty over the nut and around its sides; this will hold it in place. Put cover on and screw in the bolts. Take care not to fill the threads with the putty.

**196. Washer Spacers For "Building" Out From A Flush Device Box Which Has Been Set Too Deep are shown at** *W*

in Fig. 400. Sometimes when the electrician is setting the switches or other flush devices, he finds that the coat of plaster is unusually thick at the outlet-box location. The front edge of the outlet box (or box cover, if one has been used) may lie from ½ in. to 1½ in. back of the finished wall surface. He must then adopt some expedient whereby the *switch, receptacle,* or other device can be attached, out flush in its proper location,

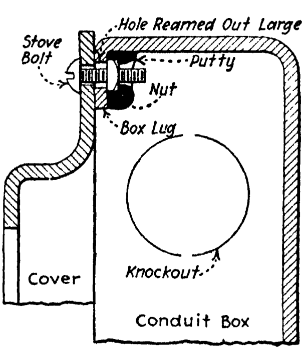



FIG. 399.—Fastening a cover on a conduit box when the screw thread is stripped.

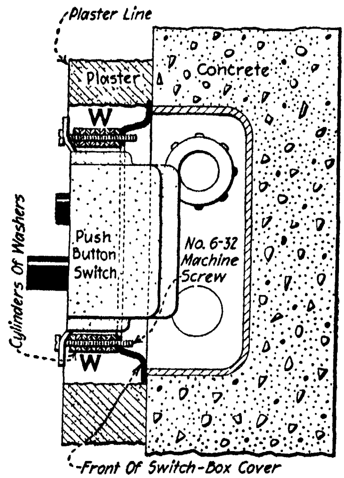



FIG. 400.—Spacer washers for "lining up" a flush device in a box which has been set too deep.

and rigidly to the box. This may be accomplished by arranging a stack of washers on a long No. 6-32 machine screw, between the device ears and the box ears, as shown in Fig. 400. *Copper burrs,* such as are used on rivets for leather, or tinner's burrs make satisfactory washers. The No. 6-32 machine screws which come with the device will probably be too short.

NOTE.—IN INSTALLING A STACK OF SPACER WASHERS, as at *W* (Fig. 400) either of two methods may be employed: (1) Stack the washers into two columns, each column of the proper height, and wrap a piece of friction tape around each stack; the tape holds the washers together and thus prevents them from falling from the machine screws when the screws are being turned into position. (2) Cut the heads from two No. 6-32 machine screws, which are sufficiently long to project about 1 in. outside of the wall face when their inner ends are screwed into the

ears of the outlet box. Turn one of these headless screws into place in each of the box ears. Place a sufficient number of washers on each headless machine screw to fill out from the box ear to the wall face. Place the device in position with its ears over the screws and press with the fingers firmly against the ears to hold the washers in place. Remove one of the headless screws and substitute a new No. 6-32 screw of proper length, clamping one ear of the device in position. Do the same at the other ear of the device. Sometimes, in emergencies, a No. 6 or 7 *wood screw* of proper length will prove a fair substitute for a No. 6-32 machine screw.

**197. Conduit Wiring In Plaster-Board Or Metal-Lath Partitions** requires special care. So-called "two-inch parti-

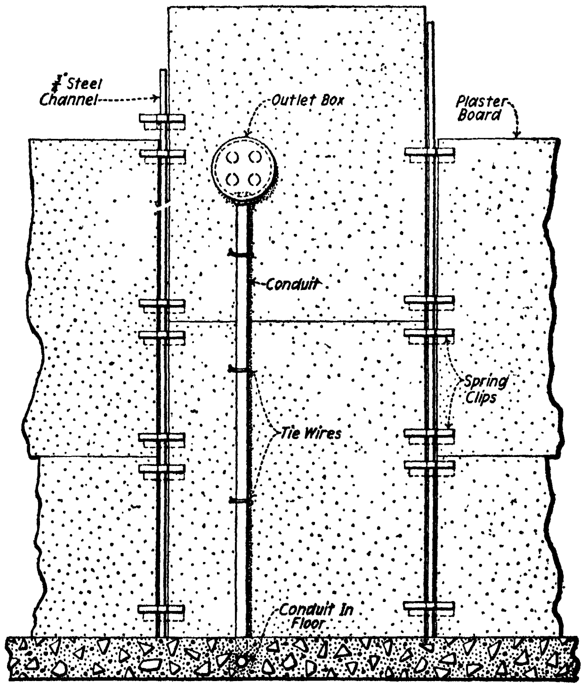



FIG. 401.—Outlet box and conduit wired to partition.

tions" are now being constructed in many buildings, particularly in those of fireproof construction. These partitions are made by applying plaster on either metal-lath or plaster-board surfaces that are supported on steel studding of small angle or channel sections. Channels ¾-in. deep are often

used in this construction to carry the plaster-board slabs which are held to the channels with steel clips as shown in Fig. 401. Because of the space economy of partitions of this type, they are being utilized in a great many cases for the subdivision of office-building floor areas. The partitions, when completed, are practically solid and comprise only fireproof materials, namely, steel and plaster. It is obvious, then, that the conduit method is the only one that is permissible within these thin partitions. Either rigid or flexible metallic conduit can be used. As a rule, it will be more economical to use rigid conduit where it is not necessary to make a great number of turns and offsets in the conduit run. However, in some cases where the route of the run is very irregular, flexible conduit may be the more economical.

**198. A Method Of Installing A Conduit Run And A Bracket Outlet Box In A Plaster-Board Partition** is shown in Figs.

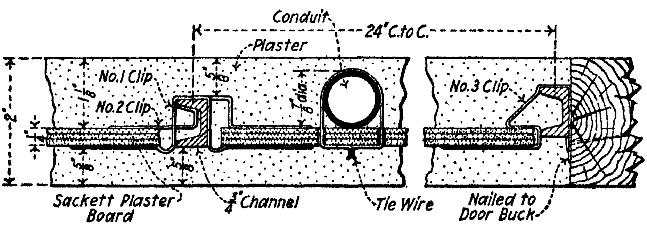



FIG. 402.—Conduit in a 2-in. plaster-board partition.

401 and 403. The conduit is installed on the partition after the plaster-board slabs have been placed and is held to the plaster board with tie wires. These tie wires (Fig. 402) pass around the conduit and through holes in the board and are twisted together on the back side of the board with a pair of pliers. This holds the conduit tightly against the board. The holes through the plaster board for the tie wires can be made with a small twist drill, turned with a bit brace. The outlet box is supported by the conduit. It will be noted from Fig. 402 that the plaster board does not lie exactly in the center of the 2-in. partition, although the channel studs do lie in the exact center. There is a distance of $\frac{5}{8}$ in. between the plaster board and one face of the partition, and $1\frac{1}{8}$ in. between the face of the plaster board and the other face of the partition.

Inasmuch as ½-in conduit is a trifle under ⅞ in. in external diameter, it is necessary to place the conduit on the 1⅛-in side of the plaster board as suggested in Fig. 402. The conduit cannot be run horizontally in the partition over studs because of the small space at the studs. Furthermore, since all outlet boxes with knockouts in the sides are more than 1⅛ in. deep, the plaster board must be cut wherever a box is placed (see Fig. 403).

NOTE.—CONDUIT RISERS IN PLASTER-BOARD PARTITIONS MAY FREQUENTLY BE PLACED IN ROOM CORNERS, or near one of the steel studs as shown in Fig 404. In such cases the conduit can be held with tie wires to the steel clips that clamp the plaster boards to the channel studs.

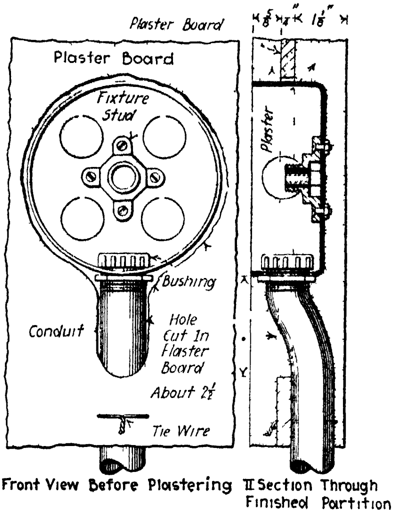



FIG. 403—Showing method of mounting a bracket outlet box in a plaster-board partition. A switch or receptable outlet box would be mounted similarly, a small rectangular box (Fig 23, Spraguelet box) being used instead

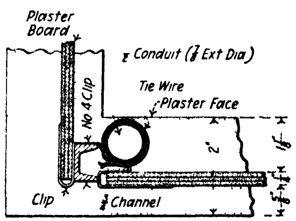



FIG 404—Conduit bound to corner clips with tie wires.

**199. An Outlet In a Plaster-Board Ceiling** can be arranged as shown in Fig. 405. There is only ⅝ in. finished plaster between the lower face of the plaster board and the finished plaster surface, so that there is scarcely room in this space for an outlet box. A ceiling plate might be used if the conduit runs were such that they could enter at the back of the plate. In most cases, however, the conduit runs will be horizontal, as shown in Fig. 405, and must enter the sides of the boxes. It will then usually be necessary to use deep boxes in plaster-

board ceilings, which will permit the conduit to enter the side knockouts.

Note.—If A Heavy Fixture Is To Be Supported From An Outlet Box in a plaster-board ceiling it will be necessary to provide additional support to the outlet box to enable it to sustain the weight of the fixture. This support can be provided by arranging a bridge across a couple of the channel-section beams, or by arranging a piece of rod or strap iron

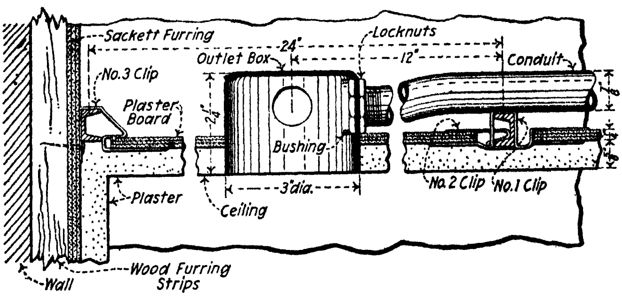



Fig 405.—Outlet-box in plaster-board ceiling.

vertically over the center of the box to some member above, so that it will be in tension when a stress is imposed on the box. Frequently a piece of No. 6 soft iron wire can be used for this tension member. It can be pushed through and tied in the screw holes in the bottom of the outlet box and made fast over a beam or around some member directly above the box.

**200. The Installation Of Flush Switches In 2-In. Partitions** is illustrated in Figs. 406 and 407. Since the depth of a shallow square outlet box is generally a little more than 1½ in., and the depth of the most shallow switch-box cover is ½ in., it is evident that the two together cannot ordinarily be placed within a 2-in. partition. For this reason it is inconvenient to install square boxes with switch covers in 2-in. partitions. But when it becomes necessary to place such a box-and-cover combination in a 2-in. partition, it is well to locate the box so that the front face of the cover extends ½ to ⅝ in. beyond the finished plaster surface. This permits of placing sufficient plaster against the back of the box to prevent cracking away. Then, to provide a neat appearance on the switch side of the partition, a wood mat (Fig. 406) is placed behind the switch plate. To obviate the use of the wood mats

under switch plates on 2-in. partitions a special shallow switch (Fig. 407) has been devised. This switch is made to fasten directly (without covers) into special shallow switch outlet boxes (Sec. 49).

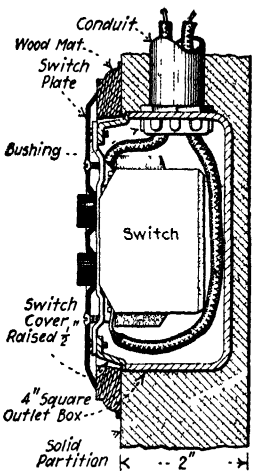



FIG. 406.—Section through a 2-in. partition containing a standard-size switch. Note that a wood mat must be placed under the switch plate because the box and switch cannot be placed entirely within the thickness of the partition.

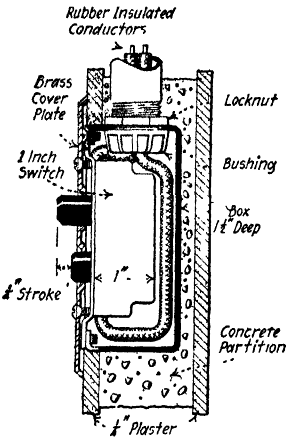



FIG. 407.—Flush single-pole "1-in." switch (*Arrow*, No. 6900) installed in 1½-in. deep wall box in a solid 2-in. partition. (*Arrow Electric Co., Hartford, Conn.*)

**201. Complicated Conduit Installations Can, By Using Templets, Often Economically Be Cut And Assembled, In A "Dummy" Installation, Prior To The Construction Of The Building.**—Templets for all of the conduit terminations are made and arranged, actual size, in a dummy layout, which duplicates the conditions that will obtain in the contemplated building. This dummy may be set up on a suitably large enclosed floor, such as that of a loft building; or it may be built out in the open. All of the required conduits are then cut, bent, and fitted into this dummy installation, just as they will ultimately be installed in the contemplated building. Every templet, conduit run, and piece of conduit is marked with an identifying number. When the building is ready for

roughing in the conduit, the dummy installation, templets and all, is disassembled and reassembled in its final position in the building. This procedure permits the construction of the building to proceed in minimum time without its having to wait for the time-consuming fitting and roughing in on the job of the complicated conduit runs.

EXAMPLES.—See *Electrical World*, July 3, 1920, for a description of the "dummy" method which is used by the Southern California Edison Co., in installing the conduit in its substations. See *Electrical Age*, July, 1917, for explanation of the application of the dummy method in installing the complicated conduit system in the Telephone and Telegraph Building, New York City.

**202. Templets For Locating Accurately The Terminations Of Conduit Runs** (Figs. 408 and 409) are often very useful

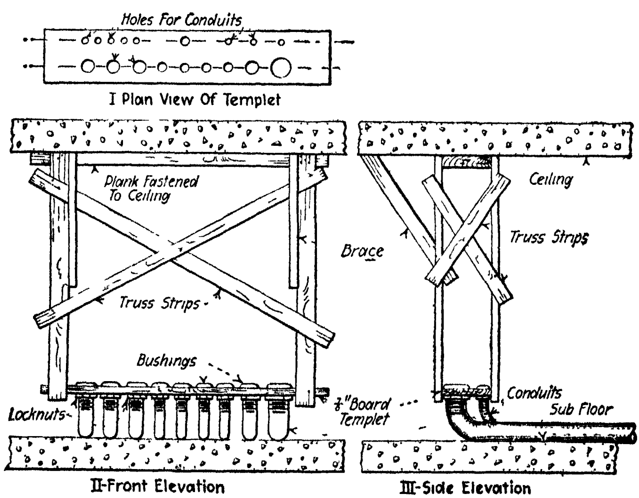



FIG. 408.—Suspended templet for conduit. (Certain of the truss strips have been omitted to simplify the illustration.)

and economical. Often conduits must terminate at certain definite locations (such as at *switchboards*, *cabinets* and *pull boxes*) and the equipment at which the conduit is to terminate is not available at the time the conduits are being installed. In such cases a templet, which duplicates the size and posi-

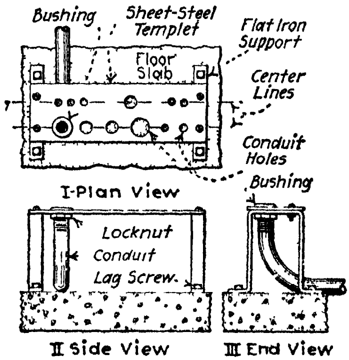



FIG. 409.—Subvened sheet steel templet for conduit, supported on a flat-iron base.

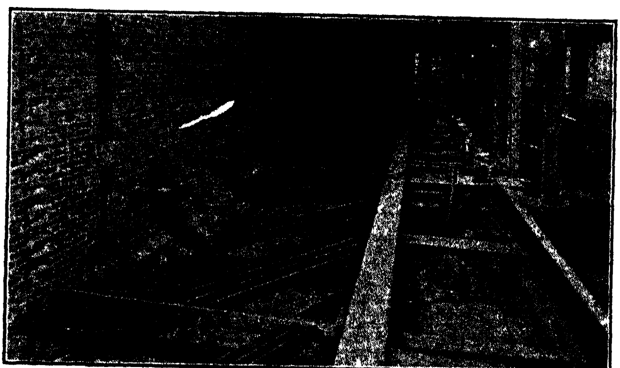


FIG. 410.—Fibre conduit in place preparatory to pouring concrete. Montana Power Company, Butte, Montana (Johns-Manville Co.)

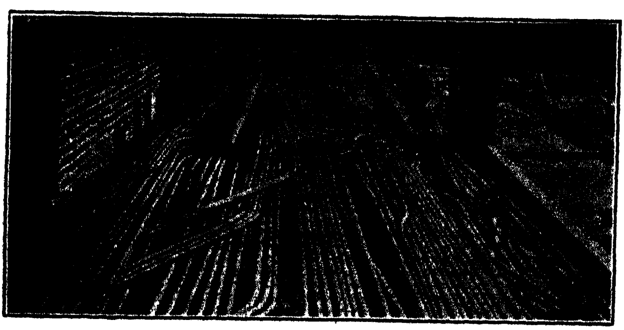


FIG. 411.—Sheraduct conduit installed for switchboard of San Diego, Cal., Consolidated Gas & Electric Company, H. M. Byllesby & Co., Engineers. (*National Metal Moulding Co.*)

tions of the contemplated termination holes, can be made. Then this templet can be mounted temporarily, though securely, in the proper location in the building and the conduits

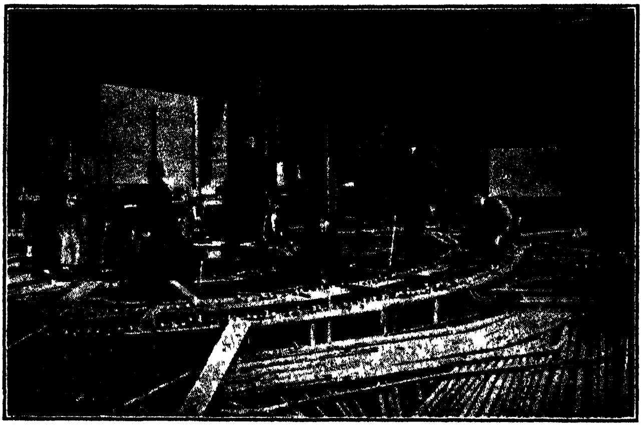


Fig. 412.—Conduits for switchboard for Generating Station A-2 of the Philadelphia Electric Co. (*Courtesy, Current News.*)

can be run to and connected into this templet just as they would to the switchboard cabinet or pull box. When the ultimate equipment finally arrives, it can, after the removal of

Fig. 413.—Conduits roughed in at cabinet location.

the templet, be installed. If the measurements have been made accurately, the conduit terminations and the equipment should "line up" and fit together nicely. Examples of such uses of templets are shown in Figs. 410, 411, and 412.

NOTE —SUSPENDED TEMPLETS FOR CONDUIT TERMINATIONS ARE USUALLY PREFERABLE TO SUBVENED TEMPLETS (those which are supported from below). That is the arrangement of Fig. 408 is, in general,

FIG. 414.—Alumaduct under switchroom floor of Niagara River Power Station, 100,000 ft of ½-in. to 2½-in. duct was used. (*National Enameling and Stamping Co.*)

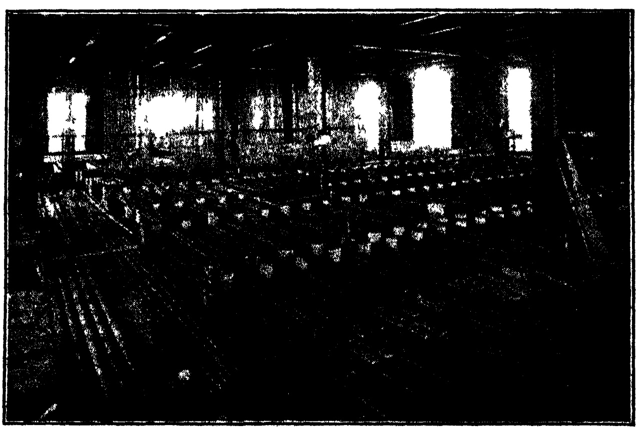


FIG. 415.—Essex Station, Public Service Corporation of New Jersey. Conduits in main floor of switch-house.

preferable to that of Fig. 409. When the templet is supported from above, there is then nothing under it to interfere with the manipulation of the conduits.

**203. Views Of Several Large Concealed Conduit Jobs** are shown in Figs. 410, 411, 412, 413, 414, 415, 416, and 417.

Fig. 416.—Essex Station, Public Service Corporation of New Jersey. Conduits connecting switch-house with turbine room.

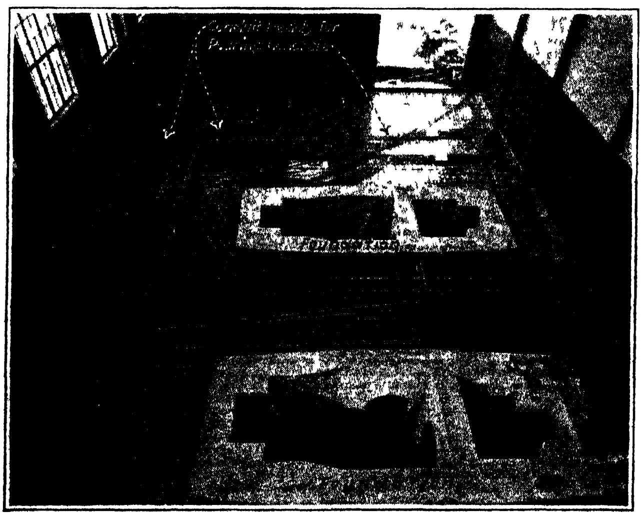


Fig. 417.—Conduit layout in the floor of a substation ready for the pouring of concrete. Note how ends are sometimes held in place with templets.

Several of these illustrations show *templets* holding conduit ends where they are to project upward or otherwise in some

special direction. The templet method is perhaps the most positive in assurance that the conduit will line up with other apparatus (such as cabinets, switchboards, or the like) to which it is to connect.

### QUESTIONS ON DIVISION 5

1. In what building construction should concealed wiring be in conduit? When must wooden-frame buildings have all wiring in conduit?

2. What is the National Electrical Code rule about the accessibility of conduit boxes? How is this rule interpreted?

3. Describe, with sketches, how conduits are installed in concrete buildings which are to have wooden floors. Give two methods.

4. Should conduit be placed before or after the concrete floor slabs are poured? Why? Explain fully.

5. Explain, with sketches, the method of fastening a conduit box to a piece of rigid conduit.

6. How many locknuts are usually employed at one conduit-box fastening? When may more be necessary? Why?

7. Draw a sketch to show the proper connection between a conduit box and a piece of conduit which was cut too long.

8. Describe the method of making a flexible-conduit fastening to a conduit box. Are bushings used? How many locknuts?

9. Draw sketches showing two methods of fastening conduit boxes to form boards.

10. Describe what may happen if concrete, during the pouring, fills a conduit box.

11. Explain two methods of preventing the accumulation of concrete in conduit boxes.

12. Why should conduit be securely fastened when placed so as to be later embedded in concrete? Draw sketches to show how this may be done.

13. Why must not conduit be permitted to rest on the form boards for a floor slab?

14. Draw sketches to show several schemes which are employed for maintaining a space between the form boards and the conduit.

15. Explain, with a sketch, how you would support conduit and conduit boxes in a steel concrete-column form.

16. At what stage in the construction of a concrete building are the large conduit risers generally installed?

17. What is a *chase?* A *wire-shaft?* What are their uses?

18. Draw a sketch to show how a chase can be formed in a concrete wall.

19. Explain, by drawing sketches, a method of installing an outlet box and its feeding conduit in a hollow-tile arch. How would you punch holes in the tile?

20. Describe the method employed for placing outlet boxes and conduit in "concrete-joist" floor slabs. Draw a sketch.

21. How should ceiling outlet boxes be supported in suspended ceilings?

22. Explain how a wireman may facilitate some of the work in a suspended-ceiling job.

23. Explain, with a sketch, how switch outlet boxes should be installed in building of fireproof construction.

24. Suppose that a partition was inaccurately located when the preliminary conduit work on a concrete building was done. How would you remedy the job so as to get a wall-outlet feeding conduit into the partition?

25. What is the procedure in installing an outlet box and conduit in an existing tile partition? Draw a sketch.

26. Draw sketches to show how outlet boxes may be supported on steel columns which are to be covered with fireproofing tile. (Show how the support is made both when the box is to be placed on the flange side and between the flanges.)

27. Draw a sketch to show how an outlet box may be supported from wooden joists with pipe fittings.

**28.** Describe several methods of supporting conduit in wooden-frame buildings and draw sketches to illustrate each.

**29.** What is the disadvantage of supporting conduit in notches in the floor joists? How may it be overcome? At what part of the joists is notching always permissible?

**30.** Draw sketches to show the correct and incorrect methods of drilling holes in joists for flexible conduit.

**31.** Discuss the question of passing rigid conduit through holes drilled in joists.

**32.** Describe and illustrate with sketches several manufactured devices for supporting ceiling-outlet boxes in wooden-frame buildings. What are their advantages?

**33.** Show by sketches several methods of supporting conduit in buildings of "steel-lumber" construction.

**34.** Explain how outlet boxes may be supported from door bucks. Draw sketches of several arrangements for this support.

**35.** How should outlet boxes be supported in stud partitions?

**36.** What are the advantages of steel supports at door bucks?

**37.** Explain the meaning of the term "flush" cabinet.

**38.** Describe the procedure in installing and aligning a cabinet box.

**39.** Draw sketches to show several methods of supporting steel cabinets in fireproof buildings.

**40.** Why are the covers for outlet boxes made "adjustable?"

**41.** Explain the procedure in aligning the cover for a flush device.

**42.** Describe the use of a straightedge for aligning several adjacent outlet-box covers.

**43.** Which is usually used in two-inch partitions, rigid or flexible conduit?

**44.** Describe and draw sketches to illustrate the method of installing conduit runs and outlet boxes in plaster-board partitions.

**45.** What is unusual about the installation of flush switches in two-inch partitions? In what two ways is the installations accomplished? Show with sketches.

# DIVISION 6

## INSTALLING EXPOSED CONDUIT

**204. The Purposes Of Installing Wiring In Exposed Conduit** (Fig. 418) are, in general, the following: (1) *To provide a conduit job at less expense than that of concealed conduit.* Exposed conduit-wiring systems have all of the advantages of concealed conduit wiring; that is, they provide a very safe, mechanically secure, and very durable wiring means. The installation of the conduit in exposed locations may often be accomplished at less expense than were it all concealed. (2) *To provide a very flexible conduit system.* Inasmuch as the conduit and all outlet and junction boxes are located in accessible places, future additions and alterations may very readily be made. (3) *To provide conduit wiring in existing buildings at low cost.* The installation of concealed conduit in existing buildings, especially those of fireproof construction would be much more costly than running the conduit exposed. Where appearances do not justify this additional expense, the conduit is run exposed. (4) *To provide mechanical protection in portions of wiring systems which are of less secure character* (such as openwork, or moulding wiring systems). The only disadvantages of exposed conduit are that, in certain cases, its appearance is objectionable and that under certain conditions it may cost more than concealed conduit.

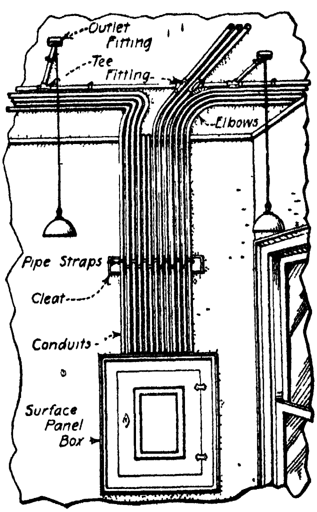


FIG. 418.—Exposed-conduit installation with surface panel box. (*Crouse-Hinds.*) The "elbows" in the above illustration should, more properly, be termed "bends."

Note.—Rigid Conduit Is Generally Used For Exposed Conduit Work because the rigid conduit can be made to present a more pleasing appearance than can flexible conduit. Furthermore, rigid conduit is to a certain extent self-supporting; that is, if the conduit is fastened at intervals (10 ft. or so), the portions between fastenings are fairly secure

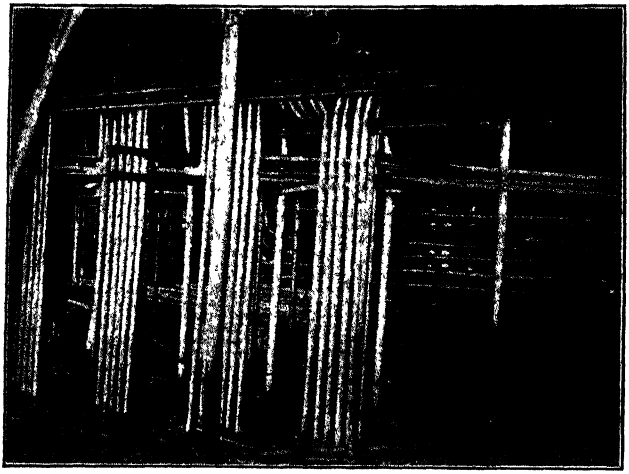


Fig. 419.—Essex station, Public Service Corporation of New Jersey. Control conduit room. All conduits for the entire switchhouse building terminate in this room.

against displacement by blows, weight, or the like (see Fig. 419). Flexible conduit, on the other hand, may readily be moved at points other than those at which it is fastened.

**205. Neat Appearance Is Essential In Exposed Conduit Work,** hence great care should be exercised in its installation.

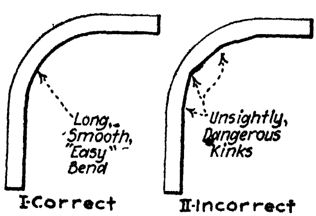



Fig. 420.—Correct and incorrect conduit bends.

Construction which is mechanically satisfactory but which does not look well may suffice where it is to be concealed.

But where the construction is to be exposed to view, unsightly work should not be permitted.

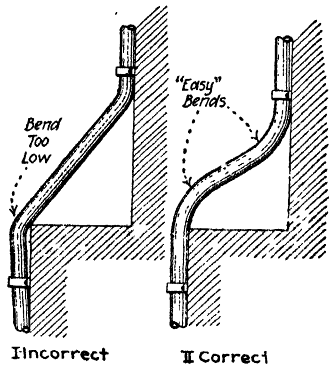



FIG. 421.—Carrying an exposed conduit run around an offset.

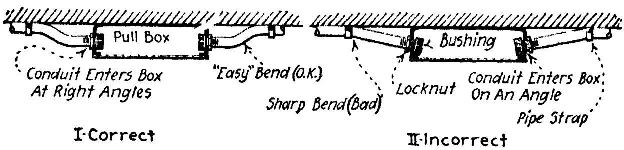



FIG. 422.—Carrying exposed-conduit ends into a box.

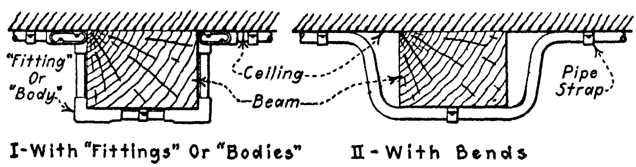



FIG. 423.—Correct methods of carrying exposed conduit runs around beams.

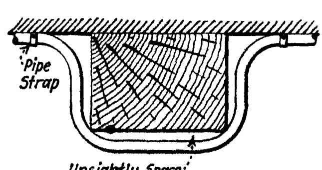



FIG. 424.—Incorrect method of carrying a conduit run around a beam.

EXAMPLES.—*Bends* (Fig. 420) should always be smooth (see Sec. 146). *Offsets* (Fig. 421) should be so made that the conduits fit the walls. *Conduits entering boxes* (Fig. 422) should do so at right angles; if they

do not, the locknuts and bushings can not be set up squarely and tightly. Hence, they are liable to loosen. *In carrying conduits around beams,* one of the methods of Fig. 423 should be followed; not that of Fig. 424. *In carrying a conduit run around a corner,* fittings or bodies (Fig. 425) are preferable to handmade bends. Always (where feasible) set a pull fitting or body (Fig. 425-*II* and-*III*) so that the long dimension of its opening lies in the direction in which the conductors will be pulled in.

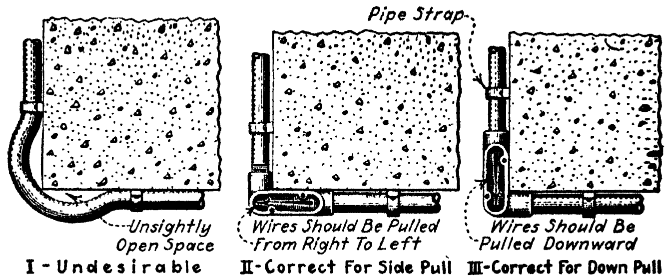



Fig. 425.—Carrying exposed conduit runs around corners.

**206. Exposed Conduit Is Frequently Used For Service-Entrance Wiring** (Figs. 24 and 426) even where other wiring systems (openwork, for instance) are employed for most of the interior wiring. This is often done to provide greater protection for the wires outside of the building and for safety to persons. Service-entrance conduit, when so installed, should run continuously to a metal switch and cutout box and should be grounded (Div. 9). Service entrance conductors which would otherwise be exposed on the outside of buildings must be installed in conduit where the conductors would be within the reach of human hands or where they would be liable to interference from movable objects.

**207. Exposed Conduit Wiring Is Often Used For Parts Of Other Systems** (Fig. 427) to protect the wiring from mechanical injury. Thus, in Fig. 427, which shows a portion of a building which was wired after the building was finished, a run of conduit extends vertically from the distribution cabinet in the first story and wires emerge from the conduit at the ceilings of the first, second, and third stories. The wires emerge through fittings which have separate bushed holes for each wire (Fig. 428) and the wires are carried on exposed cleats to the various outlets. Likewise in Figs. 429 and 430 are

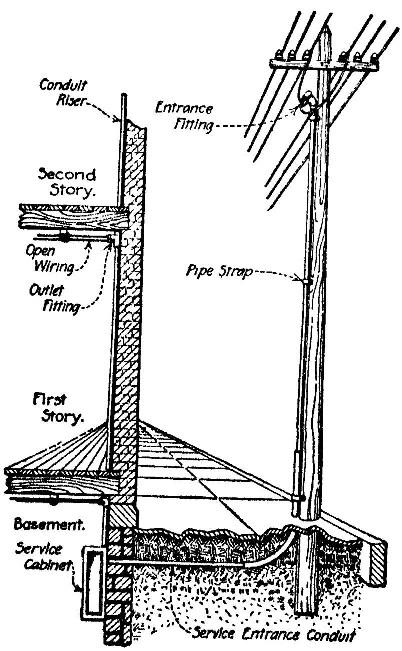



FIG. 426.—Underground-conduit service entrance. (*Crouse-Hinds.*)

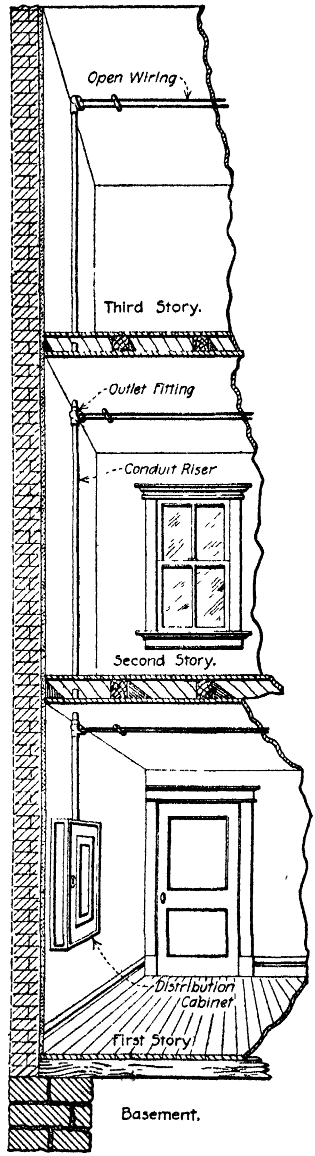



FIG. 427.—Exposed conduit riser. (*Crouse-Hinds.*)

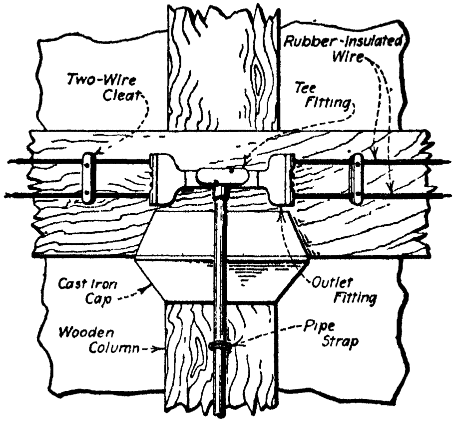



FIG. 428.—Feeding two open-wire circuits from a conduit run.

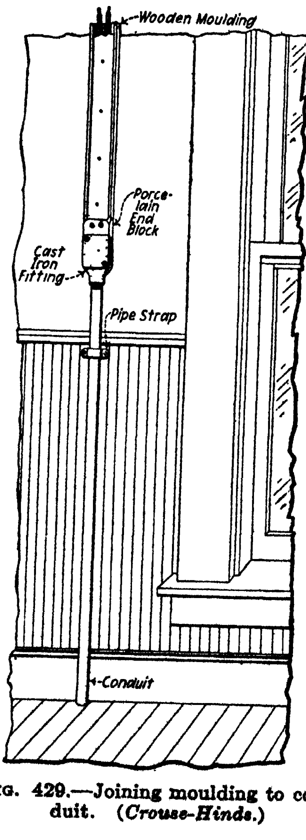



FIG. 429.—Joining moulding to conduit. (*Crouse-Hinds.*)

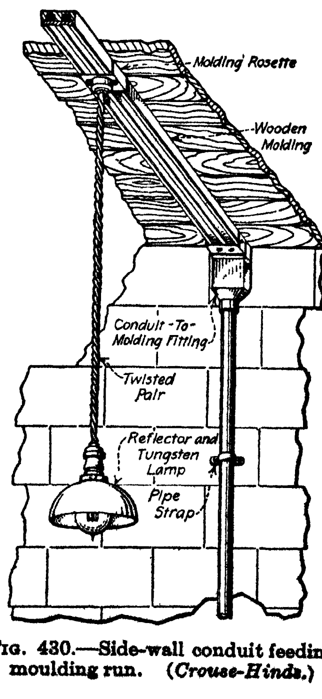



FIG. 430.—Side-wall conduit feeding moulding run. (*Crouse-Hinds.*)

shown methods of connecting conduit runs to wooden moulding.

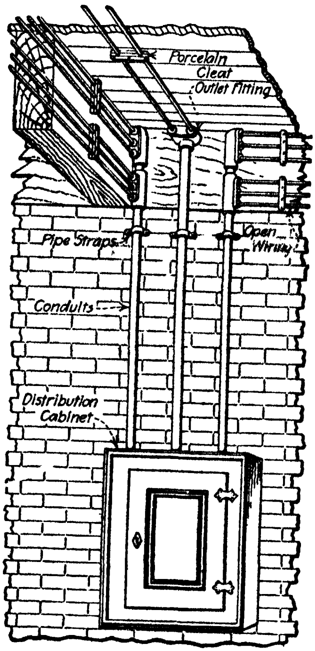



FIG. 431.—Side-wall conduits from distribution cabinet feeding open-wire circuits.

NOTE.—IT IS CUSTOMARY TO USE CONDUITS FOR EXPOSED WIRING ALONG FIREPROOF WALLS, as shown in Fig. 431. It is difficult and

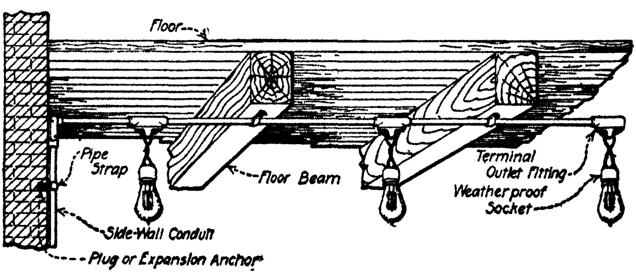



FIG. 432.—Weatherproof sockets supported from exposed conduit run. (*Crouse-Hinds.*)

laborious to secure a firm screw hold in masonry and concrete walls. This renders the installation of open wiring on such surfaces expensive

and undesirable. Since conduit can be run along a wall with only a small number of screw fastenings (see Fig. 431), it is more suitable for wiring along fireproof walls. Short runs of conduit like those shown, very frequently need not be grounded (see Sec. 305).

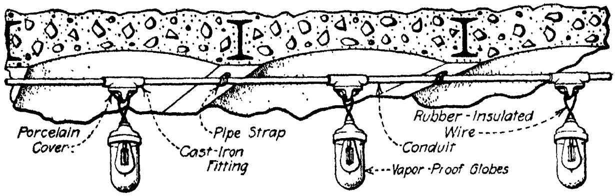



Fig. 433.—Vapor-proof globe lighting units supported from conduit run (*Crouse-Hinds.*)

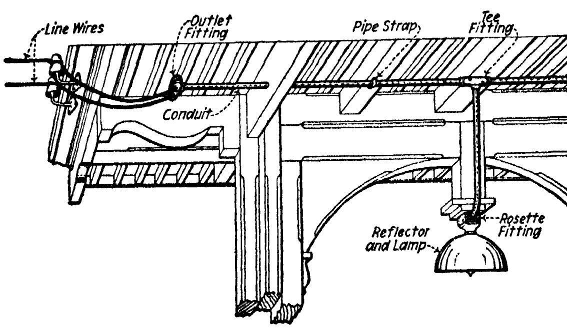



Fig. 434.—Exposed-conduit installation in a pavilion. (*Crouse-Hinds.*)

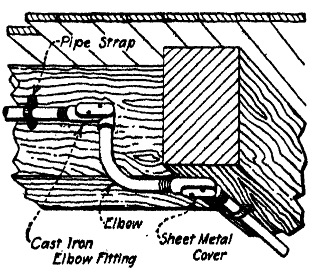



Fig. 435.—Turning from the bottom face of one beam to the side face of another. (*Crouse-Hinds.*)

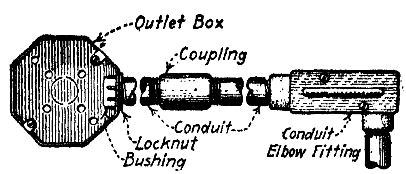



Fig. 436.—Conduit fitting used at turn in conduit run.

**208. Conduit Fittings Are Widely Used In Exposed Conduit Work** (see Sec. 30 for definition of "fittings"). These fittings, being small and specially designed for exposed conduit wiring,

present a very neat appearance. They are made in many varieties. The separator fittings (Figs. 426, 427, 428, 430, 432, 433, and 434) are used wherever wires must emerge from a

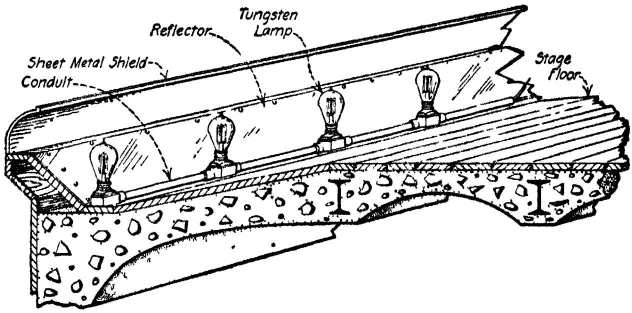



FIG. 437.—Footlight wiring. (*Crouse-Hinds.*)

conduit run. They may also be used as outlet fittings as in Figs. 432 and 433. Ell and tee fittings are made in several forms and their uses are shown in many of the illustrations in

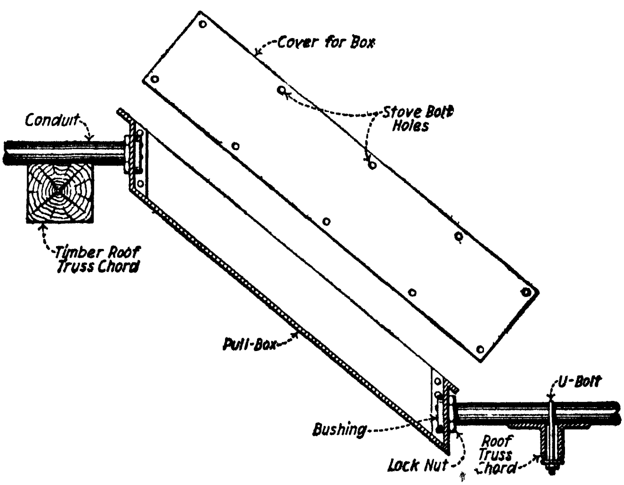



FIG. 438.—Inclined pull box.

this division. Convenient uses of these fittings are suggested in Figs. 418, 435, and 436. Conduit outlet fittings, as shown in Fig. 437, are frequently used for display, sign, and theater

lighting. In fact, fittings may be used to hold practically any wiring device that is manufactured.

NOTE.—PULL BOXES ARE OFTEN USED IN EXPOSED CONDUIT WIRING (Fig. 438).—A great deal of time is saved in the erection of a job, where a large number of conduit runs follow approximately parallel paths, by employing pull boxes (Fig. 439) instead of trying to form the conduits into the proper kinds of bends. Pull boxes are especially desirable where the runs of conduit are long (Sec. 84) or where they contain a large number of bends. Pull boxes should, in general, be placed where they will replace bends or elbows in the conduit runs. A pull box which

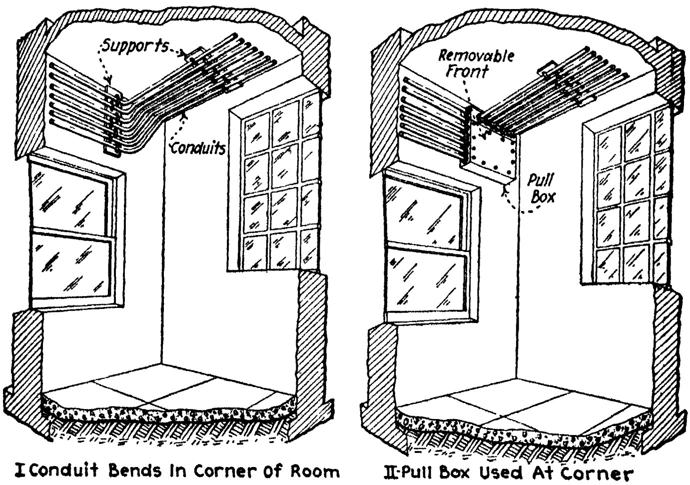



FIG. 439.—Showing how a pull box replaces bends in conduit runs.

replaces a number of offset bends is shown in Fig. 439 (see also Fig. 480).

NOTE.—STEEL-BOX ENCLOSED SWITCHES (Fig. 440) are often employed in modern installations, in lieu of a switchboard. Such an arrangement really constitutes a *dead front switchboard.*

**209. Exposed Conduit Wiring May Be Classified** as follows: (1) *Exposed surface conduit wiring* wherein the conduit is carried directly against some supporting surface (or within about an inch of that surface). Examples of exposed surface conduit wiring are shown in Figs. 418, 430, 433, 437, 439, 441, 442, and 443. (2) *Exposed open conduit wiring* wherein the conduit hangs at some distance from nearby surfaces or is carried in racks. Examples of such open conduit wiring are shown in Figs. 419, 433, 434, 435, 444, and 445. Exposed open conduit

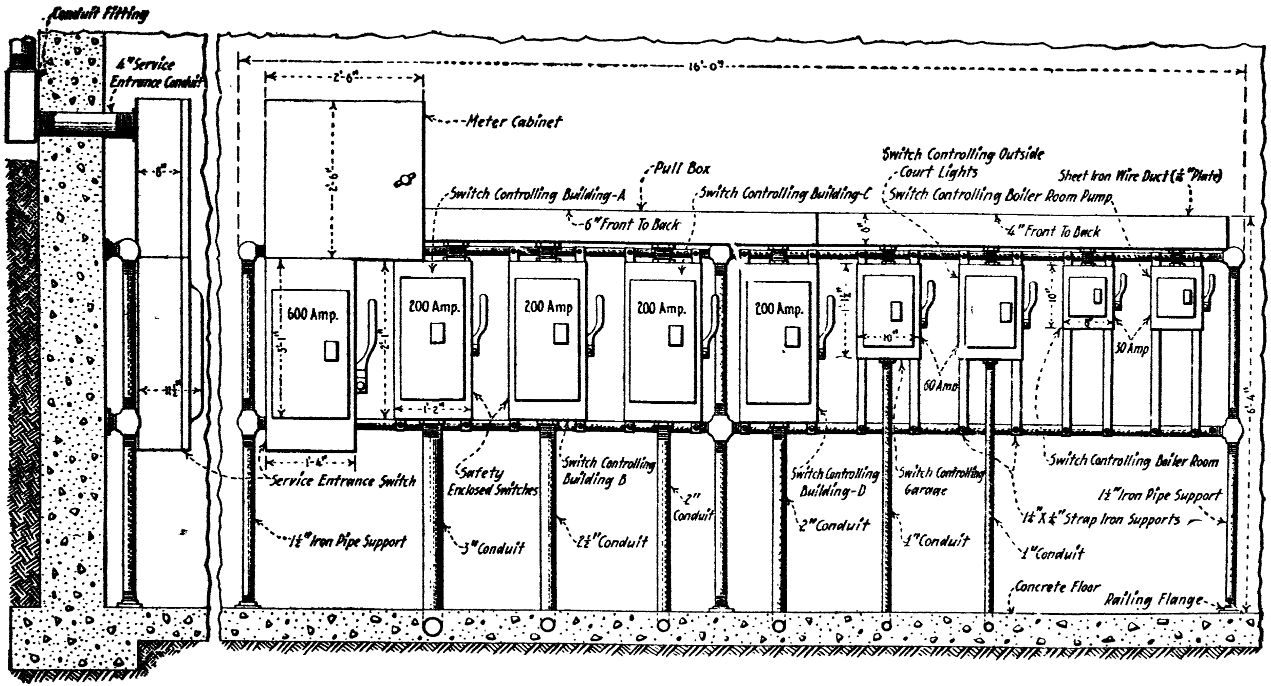



FIG. 440.—Switchboard composed of switches enclosed in steel boxes, Donaldson Apartments, St. Louis, Missouri. (*Broderick Electrical Contractor.*)

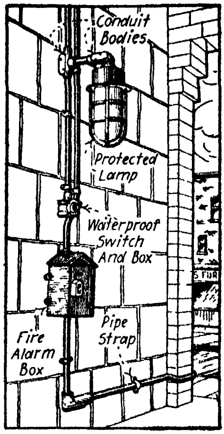



FIG. 441.—An installation of "surface" exposed conduit wiring on the outside of a building. (All fittings in exterior work must be waterproof.)

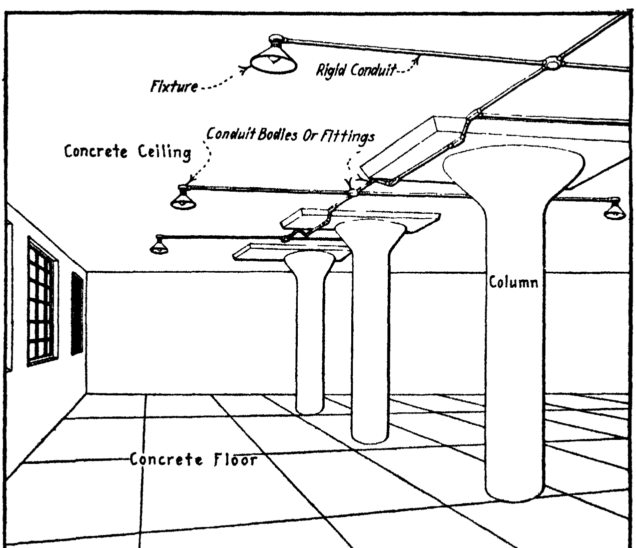



FIG. 442.—A neat installation of exposed surface conduit wiring on the ceiling of a warehouse room of reinforced-concrete construction. Note that a number of offsets might have been avoided if the conduits had been kept clear of the abacuses of the columns.

wiring, as is evident from these illustrations, is generally employed where the building construction is such that the installation of surface conduit would be difficult and expensive. Exposed surface conduit wiring, however, presents a neater appearance than does open conduit wiring.

NOTE.—EXPOSED CONDUIT INSTALLATIONS ARE FREQUENTLY COMBINATIONS OF SURFACE AND OPEN CONDUIT WIRING; that is, where

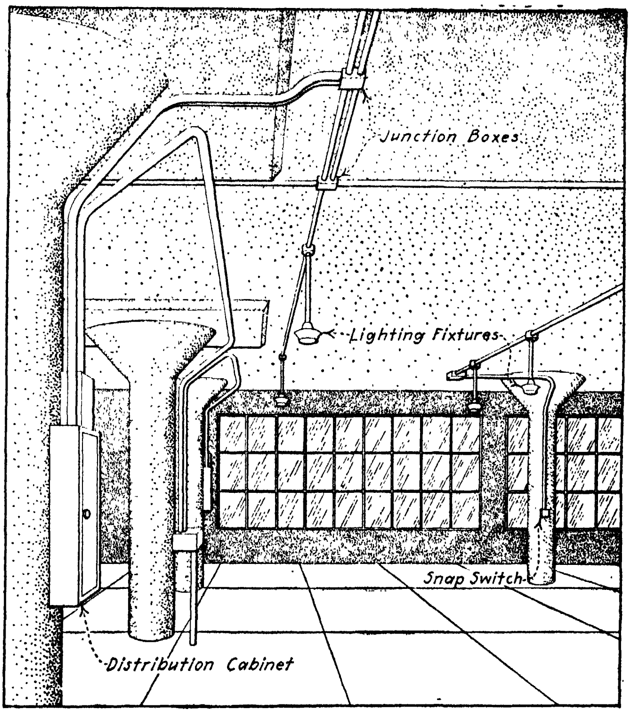



FIG. 443.—Another example of exposed surface conduit wiring. Note the manner in which the conduit runs enter and leave the panel boxes on the columns and the extensive use of junction boxes.

convenient the conduit is run along surfaces and in other places the conduit is run in the open. Wherever the conduits must be run so as to "cross" one another, as in Fig. 446, it becomes convenient to run the conduits which have one direction against the surface and to run those which have the other direction in the open.

**210. The Support Of Exposed Surface Conduit** is generally effected with pipe straps (Figs. 45 and 447). The spacing of

the supporting straps is a matter which the wireman must decide. The supports should not be spaced farther apart than

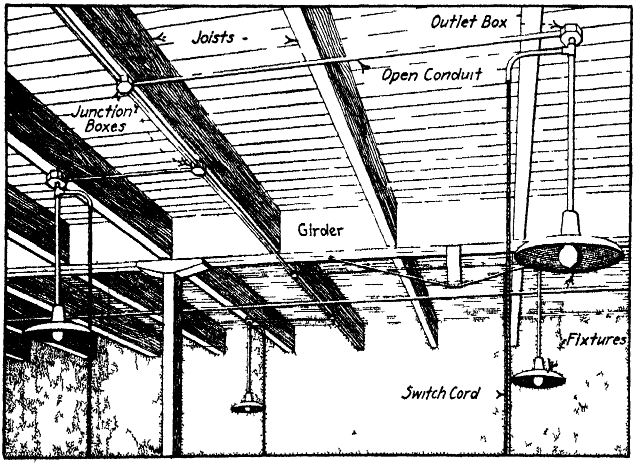



FIG 444—A typical example of exposed "open" conduit wiring

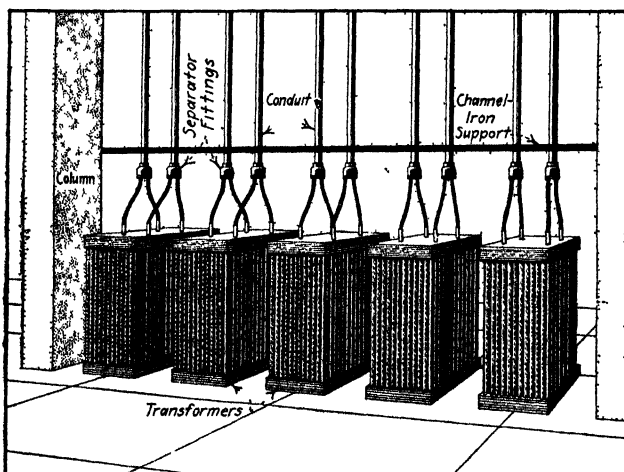



FIG 445—Arrangement of transformer leads—a good example of exposed open conduit work.

about 10 ft. Chicago rules require that every length of conduit have a separate support. Where heavily loaded large

conduit is supported by wood screws, the supports should be provided at more frequent intervals. The governing factor

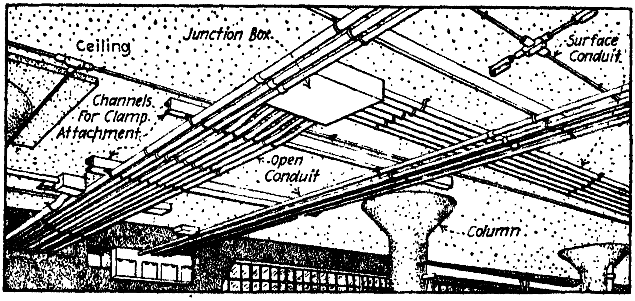



FIG. 446.—A partially completed installation of combined surface and open conduit wiring.

in the spacing is generally the strength and permanency of the fastening screws or bolts. For supporting conduit or hollow

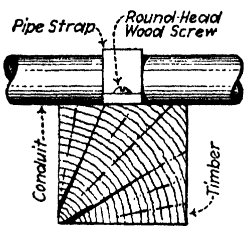



FIG. 447.—Conduit held to timber with pipe strap.

tile, toggle bolts (Fig. 448) may be used. Where the conduit is to be held to the flange of an I-beam (Fig. 449) a piece of

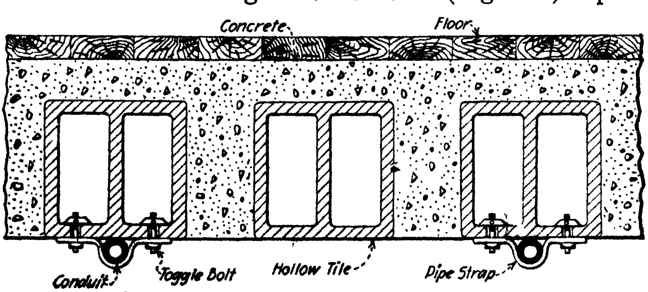



FIG. 448.—Conduit held to hollow tile with toggle bolts.

band steel may be formed into a pipe strap the ends of which may be bent around the flange.

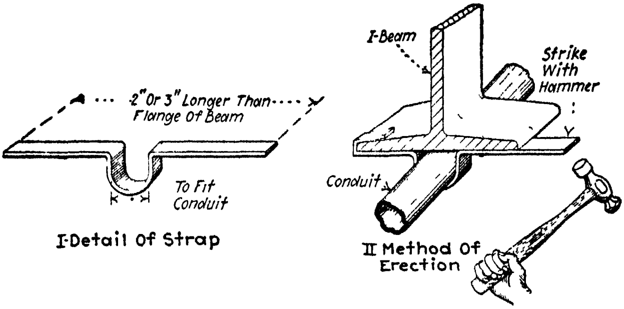



FIG. 449.—A simple hanger for holding a conduit to the flange of an I-beam.

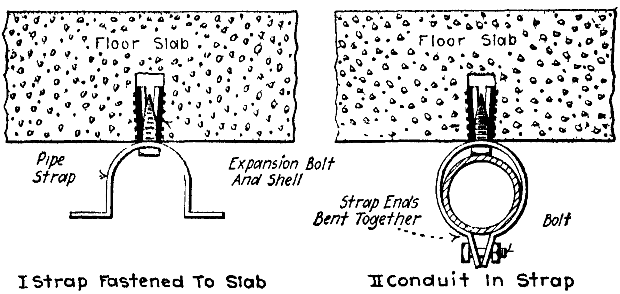



FIG. 450.—A convenient means of fastening a pipe strap to a concrete surface. Note that only one hole need be drilled in the concrete.

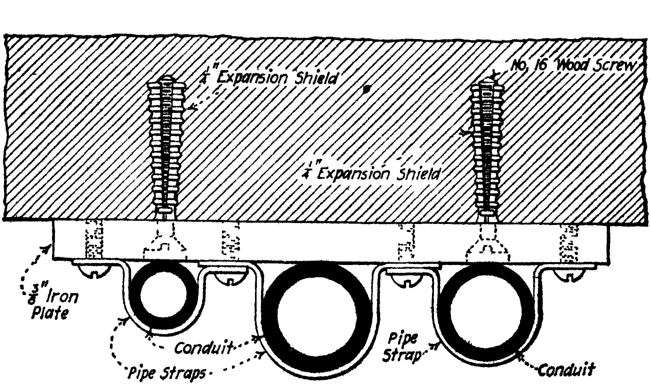



**FIG. 451.—Illustrating method of fastening a multiple conduit run to a brick or concrete surface.**

NOTE.—WHERE HOLES ARE DIFFICULT TO DRILL, PIPE STRAPS MAY BE HELD WITH ONLY ONE SCREW (Fig. 450). With this scheme the usual two-screw pipe strap may be attached by only one supporting screw. Some manufacturers sell pipe straps which are specially designed for one-screw fastening (Fig. 45). Two expansion bolts (Fig. 451) may often be arranged to hold a number of conduit runs.

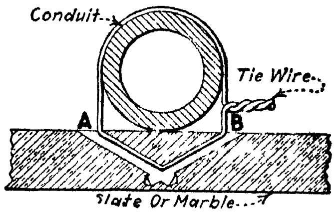



FIG. 452.—Conduit attached to panel with a tie wire. Two holes, *A* and *B* are drilled with a small twist drill, from the face of the panel, so as to intersect. Then the tie wire is fished through them.

NOTE.—FOR SUPPORTING CONDUIT ON SLATE OR MARBLE SURFACES, such as those of switch or panel boards, a tie wire (Fig. 452) constitutes an inconspicuous and, under certain conditions, a desirable support.

## 211. For Supporting Exposed Open Conduit Beneath Concrete Floor Slabs, Hangers Are Cast Into The Concrete.—

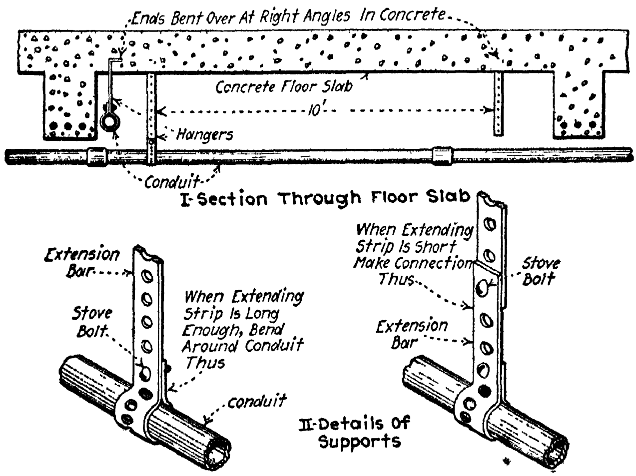



FIG. 453.—Illustrating the use of perforated extension bar for supporting conduit runs.

Either perforated band steel strip *extension bar* (Fig. 453, also called *Grabler bar*) or scrap pieces of conduit (Fig. 454) may be used in making hangers. When conduit is used, a

short piece is bent over at one end and the other end after being threaded is dropped down through a hole drilled in the

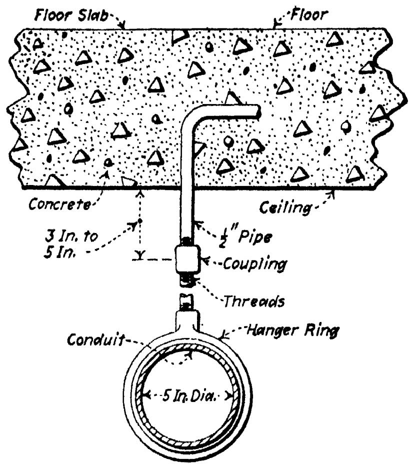



FIG. 454.—Front elevation of conduit hanger.

form boards prior to the pouring of the concrete. The upper end of the conduit piece is then wired to the reinforcing

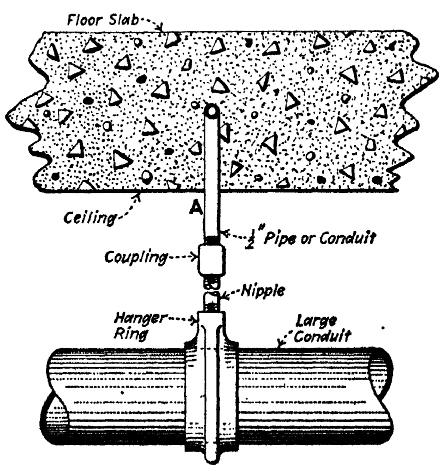



**FIG. 455.—Side elevation of conduit hanger.**

steel so that the lower end extends vertically downward through the form boards about 3 to 5 in. After the form

boards are removed, a hanger is fastened to the cast-in piece of conduit with a coupling and a nipple of the proper length (Figs. 454 and 455).

**212. When More Than One Run Of Conduit Is To Be Supported At One Location, A Complete Hanger May Be**

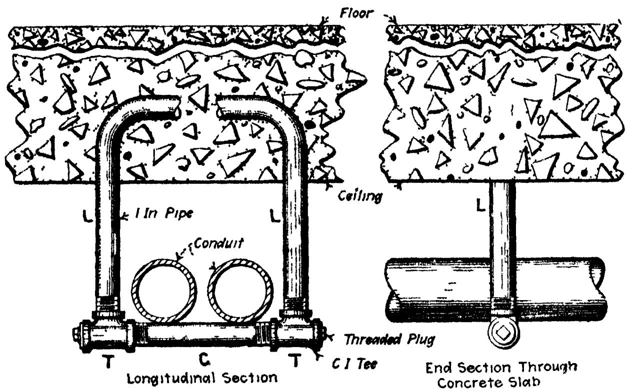



FIG 456 —Pipe support for multiple conduit run

**Constructed Of Conduit Scraps** (Figs. 456 and 457) by installing at each point of support, two extending pieces of conduit. Although it may seem wise to use up scraps of conduit by making hangers from them, the cost of the required fittings, threading, and of drilling holes through the form boards

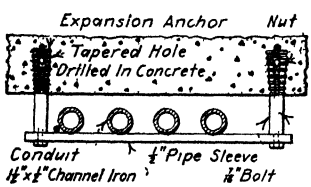



FIG. 457.—Conduit support suspended from expansion anchors.

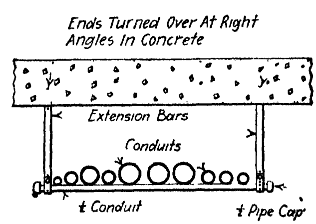



FIG. 458 —A simple scheme for supporting multiple conduit runs with perforated extension bar

more than offsets the cost of the extension bar (Fig. 453) which might otherwise be used. The bar may be driven between the form boards and with it are needed only a couple of small bolts. The method of installation is similar to that of the conduit hanger (Figs. 453 and 458).

Note.—To Select The Proper Size Of Extension Bar For Supporting Conduit Runs, it may be convenient to use Tables 213 and 214. Table 213 gives the weights of 10-ft sections of conduit assuming that

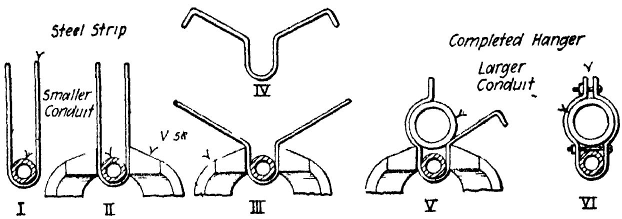



Fig 459 —Illustrating the steps in the construction of a double-conduit hanger strap

they are filled to maximum capacity with conductors. If several conduits are to be supported at one point, their weights may be added together to find the weight that the support must sustain. Table 214 gives the safe strength of extension bars. When a hanger is made as

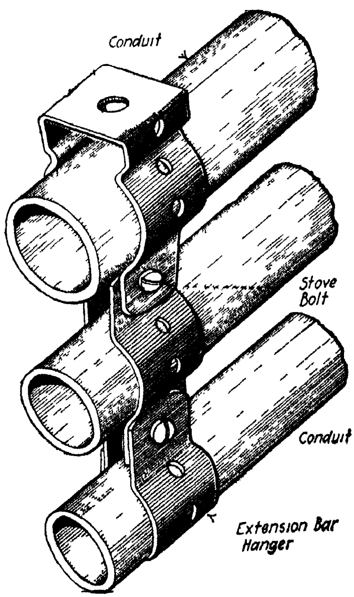



Fig. 460 —Tandem hanger for conduit made from extension bar.

shown in Fig 458, each strip sustains practically half of the total load. The process of making a tandem support for two or more conduits, one vertically above the other, is depicted in Fig. 459 ( see also Fig. 460).

**213. Table Showing Approximate Weights Of Conduit Sections 10 Ft. Long Filled With Conductors.**—The values given here include the weight of a 10-ft. section of conduit together with the maximum weight of conductors that the "Code" allows to be drawn into the conduit.

| Size conduit, in. | Weight, lb. | Size conduit, in. | Weight, lb. | Size conduit, in. | Weight, lb. |
|---|---|---|---|---|---|
| ½ | 10 | 2 | 73 | 4½ | 285 |
| ¾ | 15 | 2½ | 114 | 5 | 340 |
| 1 | 24 | 3 | 145 | 6 | 445 |
| 1¼ | 38 | 3½ | 175 | | |
| 1½ | 49 | 4 | 220 | | |

**214. Table Showing Dimensions Of Perforated Steel Expansion Bars And Their Strength.**

| Manufacturer | Mfr.'s Number | Thickness, in. | Width, in. | Perforations, diameter, in. | Net area, sq. in. | Safe strength, lb. (at 8,000 lb. per sq. in.) |
|---|---|---|---|---|---|---|
| Crane Co. . . . . . . . . . | 11 | 0 081 | 13/16 | 1/32 | 0 038 | 304 |
| | 12 | 0 084 | ⅞ | 1/32 | 0 045 | 355 |
| | 13 | 0 115 | 1 | 1/32 | 0 076 | 600 |
| | 14 | 0 105 | 1⅛ | 1/32 | 0.082 | 650 |

**215. For Supporting Exposed Open Conduit From Structural Members,** as is frequently done in steel mill buildings, many special devices are manufactured. Some are illustrated in Figs. 46, 47, and 48. Perhaps the most convenient forms of support and most readily made are the U-bolt (Fig. 461) and the hook-bolt (Figs. 464, 465, and 467). U-bolts may be readily made by threading both ends of a piece of round mild steel and then forming it with a jig (Fig. 462). The piece is clamped at its center under the lever and the ends bent down

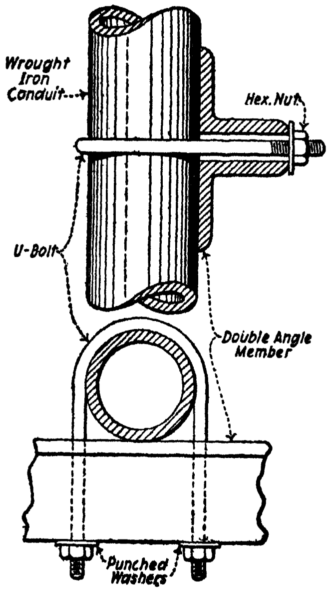



Fig. 461.—Rigid conduit clamped to a steel member with U-bolt.

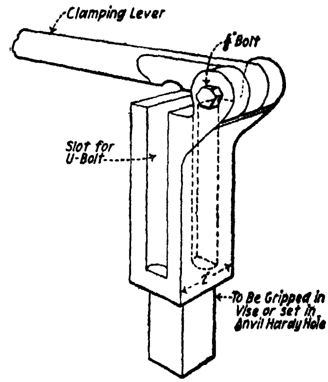



Fig. 462.—Rig for forming U-bolts.

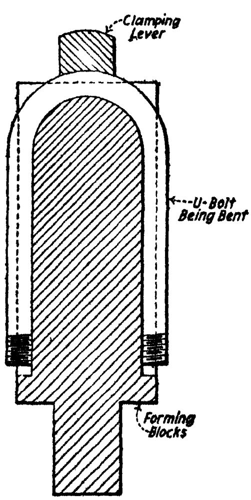



Fig. 463.—U-bolt being formed.

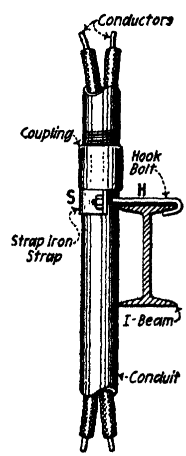



Fig. 464.—Vertical conduit supported with strap and two hook bolts.

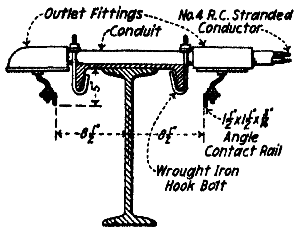



FIG. 465.—Conduit serving monorail-crane contact rails held to channel with hook bolts.

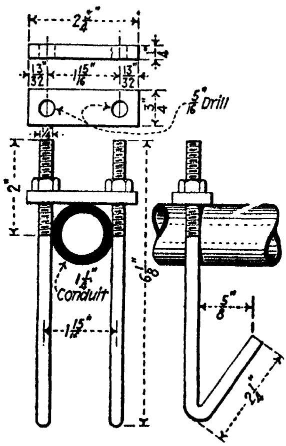



FIG. 466.—Details of hook bolts and strap for $1\frac{1}{4}$-inch conduit. See Fig. 465 for application.

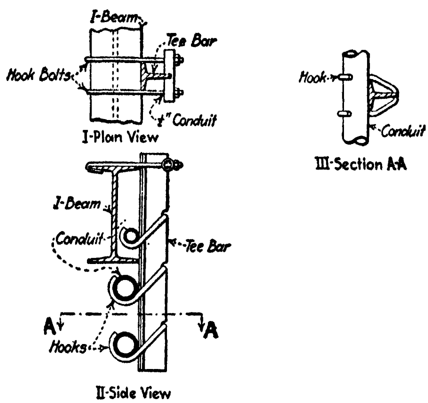



FIG. 467.—Supporting conduit runs with a tee-bar.

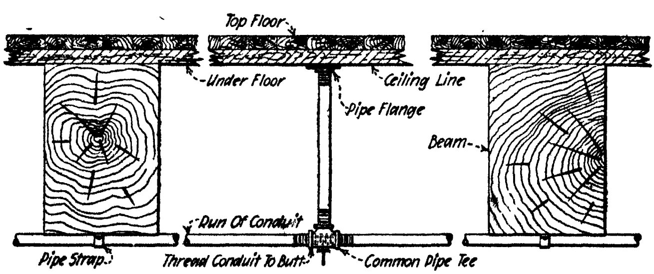



FIG. 468.—Supporting conduit from ceiling in bay center of wooden-mill construction building. Two conduit lengths may be joined in $T$, thus saving a coupling. Or $T$ may be sufficiently large that the conduit will pass entirely through its horizontal opening without engaging threads.

against the slot (Fig. 463). In forming U-bolts from stock greater than, say, ¼ in., the material will generally have to be heated. The details of a hook-bolt and strap assembly are shown in Fig. 466. A neat though rather expensive support

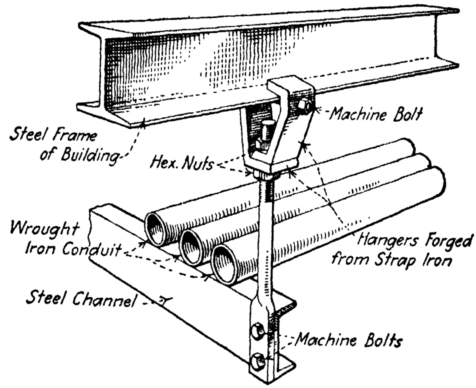



Fig. 469.—Hanger for heavy conduit runs.

(Fig. 468) may be made from a pipe flange, a length of conduit and a tee.

Note.—Various Other Readily Made Hangers And Supports are shown in Figs. 469, 470, 471, and 472.

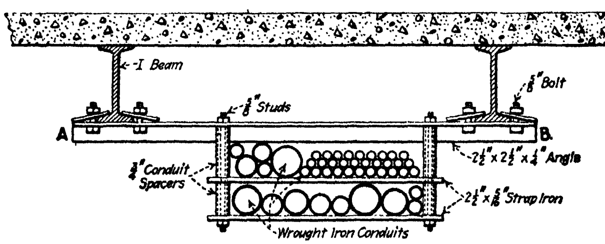



Fig. 470.—Steel support for multiple conduit run.

**216. The Support Of Long Spans Of Conduit** may be effected in one of two ways: (1) *By trussing* (Fig. 473). (2) *By cable suspension* (Fig. 474). In Fig. 473, the weight of the conduit is carried by the thin truss rods which extend between the collars *E* and *E*, passing under the center post. In Fig. 474 the conduit is suspended by straps, *S*, and turnbuckles, *T*,

from a steel suspension cable. Extension bar (Fig. 475), may for small-diameter conduits, be profitably substituted

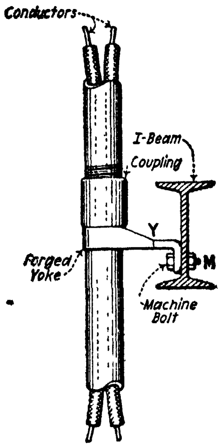



FIG. 471.—Vertical conduit supported with forged, wrought-iron yoke.

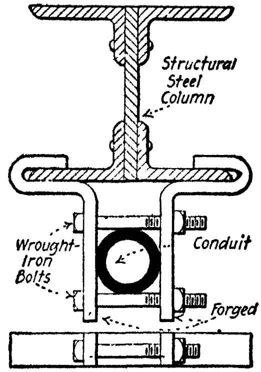



FIG. 472.—Clamp supporting conduit on face of column.

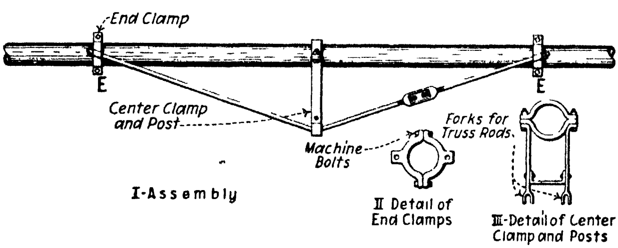



FIG. 473.—Truss support for large conduit.

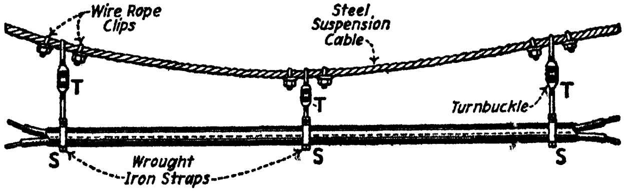



FIG. 474.—Steel-cable suspension for an aerial conduit.

for the turnbuckles and straps. Several parallel runs (Fig. 460) may be supported by a *tandem hanger* (see also Fig. 459).

NOTE.—THE SUSPENSION METHOD IS APPLICABLE TO VERY LONG SPANS, whereas the trussed support is suited only to relatively short spans (about 30 ft. being the maximum). When trussing is employed, the end clamps (*E*, Fig. 473) should be located near to the points where the conduit is supported from above or from below.

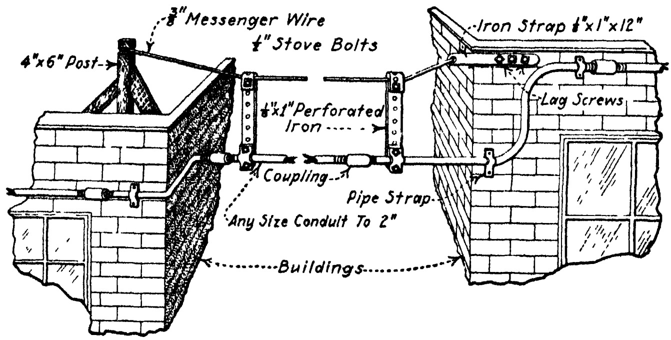



FIG. 475.—Long conduit span supported by messenger wire and extension bar hangers. The City-Of-Chicago wiring rules provide that every length of conduit must have its own support. The above arrangement satisfies this requirement.

**217. In Supporting Cabinets In Exposed Conduit Wiring,** those cabinets which have provision for the attachment of the panel in them (Fig. 477) are best supported directly against

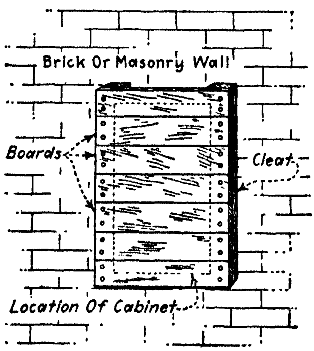



FIG. 476.—Mounting board in place ready for mounting cabinet.

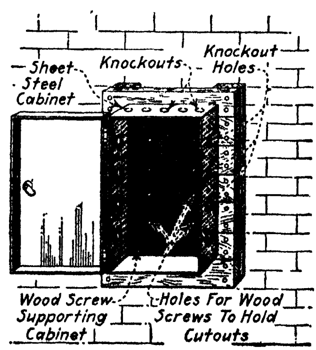



FIG. 477.—Cabinet installed on mounting board.

the wall or partition surface. They may be held with wood screws on a wooden surface. On a masonry surface, they may be held with wood screws or preferably, with lagscrews

or machine screws, all of which turn into expansion anchors. Where an ordinary stock sheet-metal cabinet is employed for containing porcelain-base cutouts or porcelain-base cutouts and switches, it is then best, if it is to be carried on a masonry surface, to mount the cabinet on a wooden mounting board (Fig. 476). The porcelain blocks (Fig. 478) are held in the cabinet with long wood screws which pass through holes in the cabinet back, which are made (Fig. 477) by the wireman to accommodate them, and into

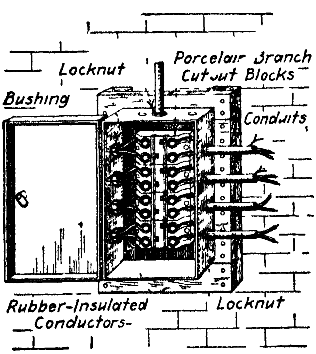



FIG 478.

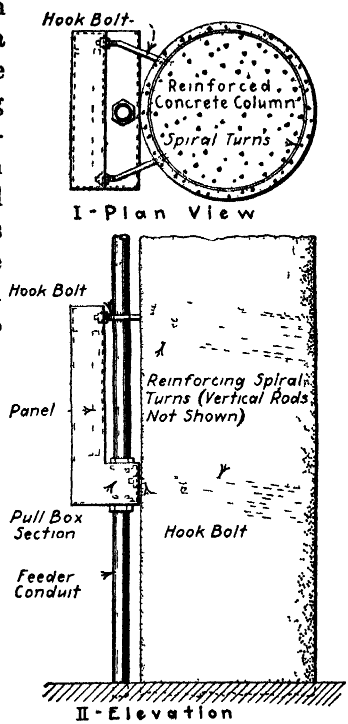



FIG. 479.

FIG. 478.—Porcelain cutouts mounted in cabinet.

FIG. 479.—Supporting a cabinet on a reinforced-concrete column with hook bolts. Four holes are bored in the concrete column. The hook ends of the threaded hook bolts are inserted into the holes until they engage the spiral reinforcing steel. The holes are then filled with cement. (*L. K. Comstock & Co., New York City.*)

the mounting board. In Figs. 479 and 480 are shown two good exposed conduit cabinet installations.

NOTE.—IN MAKING THE HOLES IN A CABINET BACK FOR THE WOOD SCREWS, lay the cabinet on the floor or bench and place the switches and cutouts in their proper positions in it. Mark the locations of the wood-screw holes with a nail, scratching through the screw holes in the porcelains onto the back of the cabinet. Spot the holes with a center

punch. Drill the holes in the cabinet back with a twist drill which is somewhat larger in diameter than that of the wood screws which will be employed.

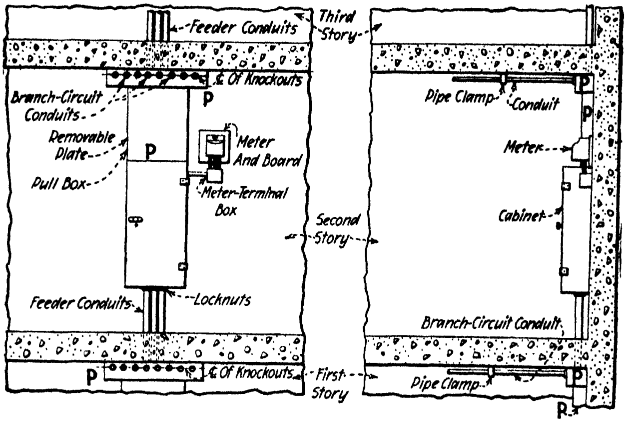



FIG. 480.—Distribution cabinet with associated pull boxes above it. The provision of the pull boxes, *P*, in conjunction with the cabinets insures a more economical and sightly installation. (*Hotel Gibson, Cincinnati, Ohio; Bert L. Baldwin & Co., Cincinnati,* engineers; *A. S. Schulman, Chicago,* contractor.)

NOTE.—A BIT EXTENSION MAY BE USED FOR DRIVING LAGSCREWS IN CONFINED PLACES (Fig. 481). Often the lagscrew holes in the backs are very close to the corners of the sheet-metal cabinets. Hence an

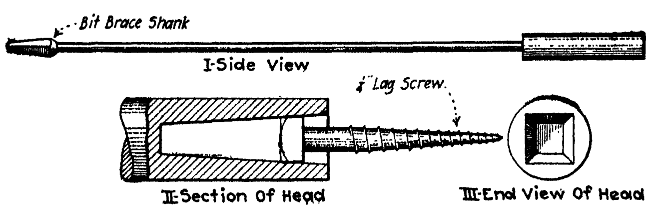



FIG. 481.—Bit extension used for driving in lag screws in restricted places.

ordinary wrench can not be used. By using a bit extension of the type shown the lagscrews may be turned in readily.

**218. The Support Of Pull Boxes On Reinforced Concrete Ceilings** sometimes becomes difficult because, in drilling holes for expansion bolts, the wireman often strikes reinforcing steel bars. One solution to this problem is the drilling of holes in the concrete before drilling the pull box. Whenever

a reinforcing bar is struck a new hole is drilled where it also can be used to support the box. In another method (Fig. 482) the boxes being first fitted with the steel strips, *S*, shown in *III*, are supported temporarily from the floor, against the ceiling. Then the lagscrew holes are drilled in the concrete. If the drill strikes a reinforcing rod in the concrete, it is only necessary to drill at some other point equally distant from the corner of the cabinet and to shift the iron strip around, as shown in Fig. 482-*II*.

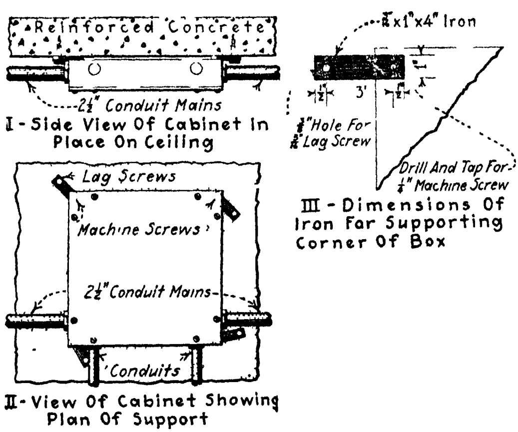



FIG. 482.—Scheme for supporting a pull box from a reinforced-concrete ceiling.

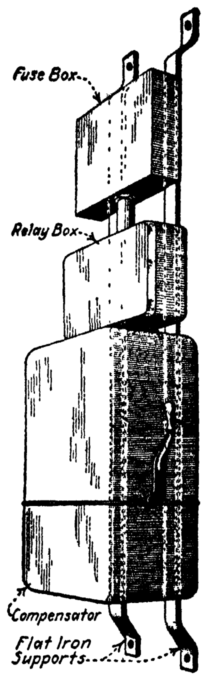



FIG. 483.—Showing how a starting compensator, relay box, and fuse box may be assembled in the electrician's shop.

NOTE.—IN INSTALLING MOTOR-STARTING APPARATUS, much time can be saved by assembling the several pieces onto a steel support (Fig. 483). This work may be done in the electrician's shop where better facilities are available than on the job. The installation of the starting apparatus then requires only the drilling of four holes for supporting the framework.

**219. In Making Attachments With Screws To Masonry Surfaces** (brick, stone, or concrete) a hole is first drilled in the surface at the point of attachment. Then into the hole is inserted either: (1) *A wooden plug* (Fig. 484). (2) *A soft*

*metal plug.* (3) *An expansion anchor.* *A wood screw* (for light loads), or a *lagscrew* for heavy loads, is turned into the

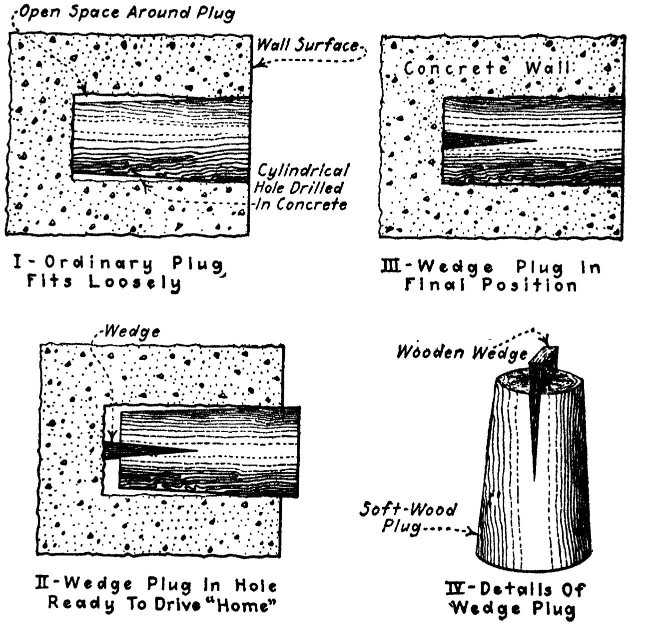



FIG. 484.—Wooden plug for insertion in masonry surfaces, to provide for the attachment of objects with wood screws. An ordinary taper plug, as at *I*, will usually be or become loose. But a wedge plug, *II*, *III* and *IV*, will often provide a satisfactory attachment. The wedge plug is made by cutting a slit in the small end of the plug with a knife and, prior to driving, inserting in the slit a properly shaped sliver of wood. This sliver acts as a wedge when the plug is driven "home," as in *III*.

plugged hole to effect the attachment. The holes may be drilled with a hand drill (Fig. 485) and hammer or, if there are

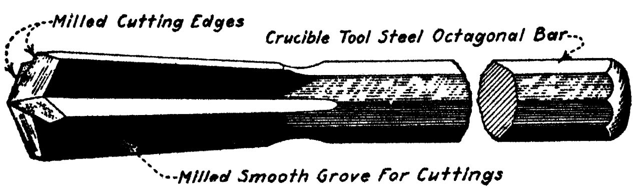



FIG. 485.—Four-point, pointed-face star drill for concrete.

many holes to be made, an electric drill (Fig. 486) or an air drill will prove a profitable investment.

NOTE.—FOR PLUGGING THE HOLES, commercial lead, or for large sizes malleable iron, *expansion anchors* (see the author's "Machinery Foundations and Erection") are preferable and economical. Improvised *metal plugs*, as described below, are satisfactory but not economical. *Wooden plugs* (Fig. 484) always tend to dry out and become loose; hence should be avoided. If wooden plugs must be used, they should be made as in Fig. 484-*II*, -*III* and -*IV*.

NOTE.—IN SELECTING DRILLS FOR MAKING SMALL HOLES IN MASONRY, a four-point *star drill* with a pointed face (Fig. 485) will prove most satisfactory for all around work. This is the best *drill for concrete*. It is regularly manufactured in diameters of from 1 in. down to ¼ in. For making holes in *brick* the *drill* of Fig. 487 works very well. A good *stone* drill (Fig. 488) should have a pointed face. An improvised *drill* (Fig. 489) can be readily forged from tool steel stock. Drills for concrete should not have their cutting edges tempered too hard or they will break badly. First *temper* the cutting edge "rather soft" and then harden it as the cutting proceeds, if justified. When a large diameter hole is to be drilled, first drill a guide hole with a small drill and then finish with a large drill. Always use as small and as short a drill as will suffice.

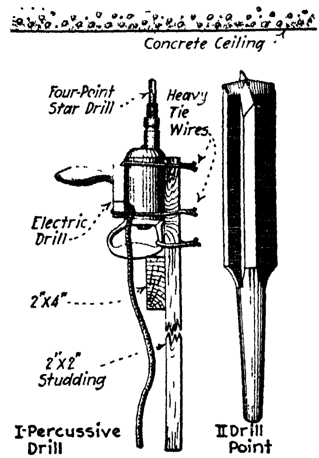



FIG. 486.—Electrically-operated percussive drill adapted for making attachment holes in concrete ceilings. The use of this arrangement is more economical and safer than working from a stepladder.

NOTE.—IMPROVISED METAL PLUGS FOR ATTACHMENT SCREW HOLES may be made by the wireman if the commercial lead (or iron) expansion anchors are not available. The commercial anchors are always the most

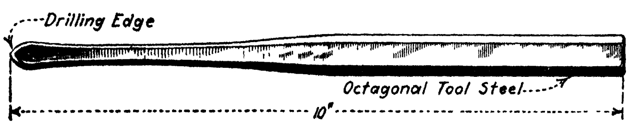



FIG. 487.—Brick drill, suitable only for drilling relatively soft masonry.

desirable and economical. A satisfactory plug may be made by using a piece of *sheet lead* which should be packed tightly in the hole by hammering on it. Use a large nail which has its point sawed off square, or a square end punch, for driving against the lead. *Solder wire* can be driven into the hole to fill it, if lead is not at hand. Preferably, the sheet lead should be rolled into a cylinder prior to its insertion into the

hole. After the hole has been packed full of the soft metal, make a hole in the metal for the reception of the wood screw. Do this by driving a nail or center punch into the center of the metal. The screw hole should be somewhat smaller in diameter than that of the wood


FIG. 488.—Pointed-face stone drill. This is regularly manufactured in diameters of from $\frac{3}{8}$ in. up to $1\frac{1}{4}$ in. and in lengths of 12, 18 and 24 in.

screw. Do not make the screw hole too large or the attachment will be insecure.

NOTE.—A VERY SECURE METAL-PLUG ATTACHMENT (Fig. 490) may be made thus: For example, drill a $\frac{1}{2}$-in. diameter hole $1\frac{1}{2}$ in. deep

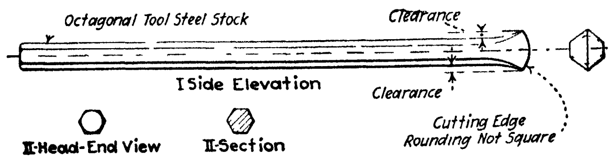



FIG. 489.—Homemade hand drill for masonry. This tool will work fairly well in concrete. In an emergency, one can be forged from steel reinforcing bar.

in the masonry. Now, on a 2 in. × $\frac{3}{16}$-in. flat-head stove bolt, wind spirally wire solder for about $\frac{3}{4}$ of the length of the bolt. Insert the solder-wound bolt in the hole. Next drive with a hammer against the solder in the hole using a piece of $\frac{3}{8}$-in. gas pipe about 5 in. long, which

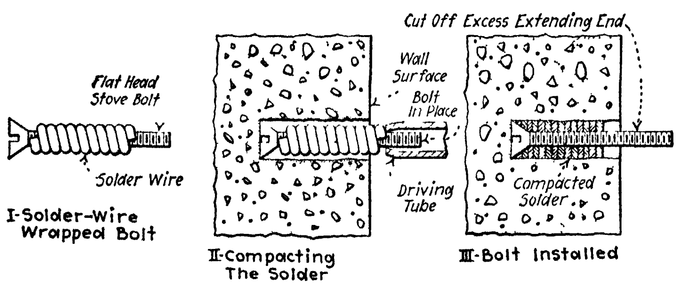



FIG. 490.—Method of holding an attachment bolt with a solder-wire anchor.

has had its working end hammered down so that the round hole in it will just admit the stove-bolt shank. This hammering compacts the solder and secures the bolt in the hole. Long stove bolts and relatively deep holes are preferable; if the hole is too shallow the masonry is liable

to break out at the surface. After the attachment has been effected (Fig. 491) by screwing the nut on the bolt, the portion of the bolt which then extends beyond the nut may be cut off with nippers or bent off with pliers. For supporting heavy loads, a carriage bolt (or a machine or stove bolt which has a washer under its head) may be installed as in Fig. 490. Sheet lead may be used instead of solder wire.

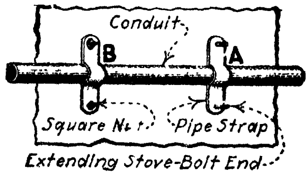



FIG. 491.—Attachment with anchored stove bolt. At $A$ the stove bolt ends are shown extending. At $B$ the nuts have been put on and the surplus bolt ends cut off.

## QUESTIONS ON DIVISION 6

1. Give and explain four reasons for employing exposed conduit in the wiring of buildings.
2. Which is better suited for exposed work, rigid or flexible conduit? Why?
3. Why is exposed conduit frequently employed for service-entrance wiring when other wiring systems are employed for the remainder of the wiring in the building?
4. What rules must be observed in using exposed conduit for service-entrance wiring?
5. When is exposed conduit often employed for parts of other wiring systems? Draw a sketch of such a combined system.
6. What construction must be employed at points where wires emerge from conduit?
7. Why is exposed wiring along fireproof walls often run in conduit?
8. Why are conduit fittings so widely employed in exposed conduit wiring? Name some uses to which these fittings may be placed. Name as many wiring devices as you can that can be held in conduit fittings.
9. Are pull boxes often employed in exposed conduit wiring? Why?
10. Name the two classes into which exposed conduit wiring may be divided. What are the characteristics of each class?
11. When are combinations of the two classes of exposed conduit wiring used and why?
12. What means are generally employed for the support of surface exposed conduit?
13. What is the usual spacing of supports for conduit? When should closer spacing be employed?
14. How may conduit be supported against a hollow-tile surface? Draw a sketch to illustrate.
15. Show by a sketch how conduit may be held to the flange of an I-beam.
16. Draw a sketch to show how a pipe strap may be held to a surface with only one screw.
17. Describe how hangers are cast into concrete floor slabs for the support of exposed open conduit. What materials are used for the hangers?
18. Explain, with sketches, how conduit is fastened to hangers which have been cast into concrete floor slabs.
19. Explain how you would select the proper extension bar for supporting a single or a multiple conduit run.
20. Describe the two classes of support that are most useful for attaching conduit runs to structural steel members.
21. Explain, with sketches, how U-bolts may be made.

**22.** Draw sketches of a number of useful connections for fastening conduit to structural steel members.

**23.** Explain and draw sketches of two methods of carrying conduit over large spans.

**24.** Which of the methods given in answer to the preceding question is more widely applicable? Why?

**25.** Explain the difficulties which are often encountered in supporting pull boxes under concrete floor slabs. Describe, with sketches, two methods for overcoming these difficulties.

**26.** How may the work of installing motor-starting apparatus in an exposed conduit job be simplified? Draw a sketch to illustrate.

# DIVISION 7

## INSTALLING THE CONDUCTORS IN THE CONDUIT

**220. The Conductors Should Not be Installed In The Conduit Until All Mechanical Work In The Building Has Been Completed,** as far as possible (Rule 503*j*, N. E. C.). Usually they are installed after the plastering has dried and hardened. If mechanical work, such as nailing, is permitted after the insertion of the conductors, there is a possibility that the nails may penetrate the conduit or that the conduit may be mashed together. Such actions would in all probability wedge the conductors, in the conduit and prevent their removal, thereby defeating one of the purposes of the conduit. If a nail were driven into the conduit it might, in addition to the above, cause a short-circuit between the conductors which would necessitate their removal.

NOTE.—THE NATIONAL ELECTRICAL CODE RULE 503*e* specifies that interior conduits "must be first installed as a complete conduit system, without the conductors." In other words, the contour and layout of the conduit runs must be such that the conductors can be inserted or withdrawn at any time. The reasons for this requirement, are the same as those for Rule 503*j* stated above. A full discussion of the "Code" is given in the author's "Wiring For Light and Power."

**221. Identifying The Two Conduit Cases Of Each Conduit Run** is frequently one of the first steps preparatory to fishing; that is, the wireman should know at what conduit case each of the runs, from the distribution box at which he is working, terminates. When, as often occurs, there are many conduits entering the same distribution box, it is sometimes difficult to identify in the box the certain conduit which it is desired to fish which extends from some conduit case in a distant room to the box. One of the best methods of thus locating the given conduit is that described in the following example:

**EXAMPLE.—It is desired to know which of the conduits terminating in the panel box *B* (Fig. 492) extends from outlet box *O* in a distant room.**

The conduit run, $OE$, can be identified by inserting the hose of an air pump, $P$, into the mouth of the conduit in the distant room as shown in the illustration and then operating the pump. Meanwhile the wireman's helper by passing his thumb successively over the mouths of all the conduits which enter $B$, can thereby easily detect, by virtue of the escaping air, the one through which $P$ is creating a pressure. Sometimes it is advisable to moisten the thumb, when holding it over the holes in the bushings, so that the conduit sought may be more readily identified. While the thumb will cover the hole in a bushing of a one-half-inch conduit, it will not close the orifice of bushings for conduits of the larger

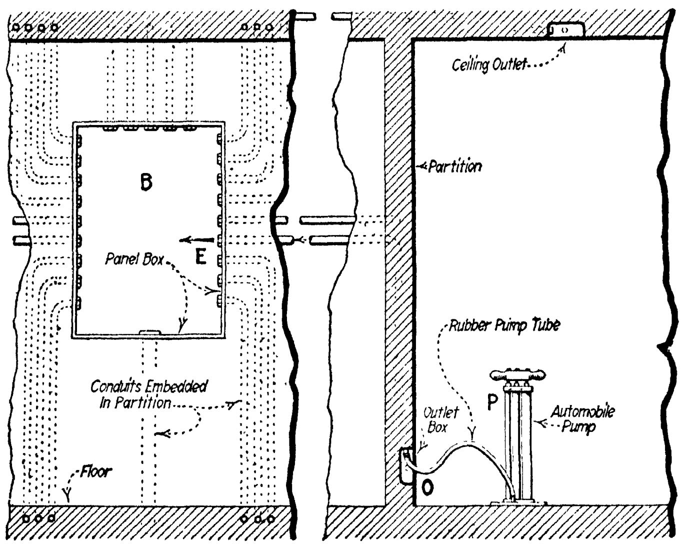



FIG. 492.—Method of tracing conduit runs with pneumatic pressure.

diameters. Hence, for these larger-diameter tubes, a piece of cardboard large enough to cover the bushing orifice should be provided. Then in this cardboard disc a ½-in. diameter hole, which the thumb can easily cover, should be pierced. To identify a conduit with the cardboard disc, it is held with the thumb over the hole in it in succession over the different conduit ends in the distribution box.

**222. The Methods Of Installing Conductors In Conduit Runs** which are in position, may be classified under two headings: namely; (1) *Drawing*, (2) *Pushing*. *Drawing* consists in pulling the conductors into the conduit by means of a pulling-in line (Sec. 262) of some sort, to which the conductors have been temporarily attached. *Pushing* consists in forcing the conductors through the conduit run, from one of the

outlets by exerting manual pressure on them. This method is applicable only where the conduit run, in which the conductors are to be installed, is short and straight. It can be used to advantage where No. 14 solid rubber-insulated twin wire is installed. Of the two methods that of drawing is most commonly used, since the instances in which the method of pushing can be followed advantageously are comparatively few.

NOTE.—ANOTHER METHOD OF INSTALLING CONDUCTORS IN CONDUIT, CALLED THREADING, consists in pushing the conductors through the conduit as it is erected length by length. This method is used to some extent in England and on the continent but the "National Electrical Code" ("N. E. C.") in the United States does not permit its use. The objections to this method with the "N. E. C." ruling are given in Sec. 220.

**223. The Conduit Must Be Fished If** the conductors are to be *drawn* into it. By the term "fishing" is meant the process of forcing a stiff wire or cord (*fish wire*) from one conduit case through the conduit system to another conduit case. After the conduit has been fished, the insulated conductors can be pulled into it either with the wire or cord used in fishing, or with a stronger flexible line (*pulling-in line*), fish wire, or cord. In either case the fishing process must precede the pulling-in process.

NOTE.—FISHING THE CONDUIT IS NOT NECESSARY, when the conductors are *pushed* into it. This procedure is economical for short runs containing only one or two bends; such as the runs from a wall switch outlet to a ceiling or bracket outlet. However, for longer runs or runs with more bends, it is more economical to first fish the run and then draw in the conductors. The wireman will soon learn which runs are more economical to "push" and which are not.

**224. It Is Best, Where Possible, To Fish Toward The Distribution Cabinet** from the conduit box or fitting which it is desired to fish. With this method it is not necessary to identify the conduit box or fitting because the wireman knows he must come out at the distribution cabinet. Another advantage of this method is that the fish wire, provided the conductors are fed in at the distribution cabinet (which is the desirable place for feeding them), can be drawn back by the wireman who is doing the fishing. This eliminates the

necessity of having to carry the fish wire from one wireman to the other. When pulling-in conductors, they should be fed in at the distribution cabinet because with this arrangement the coils of wire need not be carried from conduit box to conduit box. All can be concentrated at one location, from which many outlets can be "pulled."

NOTE.—IN FISHING SHORT RUNS, WHICH EXTEND BETWEEN A CEILING OUTLET AND A WALL SWITCH, it is usually advisable to fish from the switch outlet to the ceiling outlet. With this method the wireman doing the fishing may stand on the floor and not on a stepladder. However, in large-sized conduits, since it is difficult to fish a wire up a run, the process may have to be reversed. The conductors in all cases should be fed in at the ceiling outlet.

**225. The "Fishing" And "Pulling-In" Of A Run Generally Follow One Another In Immediate Sequence.**—By this is meant that one run is first fished and then pulled-in before another is fished. This arrangement is much more economical than that of first fishing all the runs and then pulling-in all of them. In some installations, certain conductors are not to be installed immediately. Where this occurs, it is advisable, and often required in the specification, to fish the run and leave a pulling-in line in the conduit. This should be done to guard against obstructions and omissions in the conduit system. It is more economical to cut out an obstruction in a conduit system while the building is being constructed than to do so after it is completed.

NOTE.—BEFORE FISHING AND PULLING-IN CONDUCTORS, ALL ARRANGEMENTS SHOULD BE MADE so that the work can proceed without interruption. The work should not be started until practically the entire building is in condition to receive wire. An adequate supply of wire and the necessary tool equipment must obviously be on hand. Wiring plans (Sec. 76) should be furnished to the wiremen showing the exact run of all wires and the number of wires in each conduit. This allows the contractor to study the layout with a view to economies and also avoids interruption of the work. The pulling-in of the wires should not be interrupted to skin ends or make splices, although splicing may be started by a separate gang after the pulling-in is well under way.

**226. The Branch Circuit Wire** is easy to provide for since it can be bought in standard lengths; usually in 500-ft. coils. The coils can then be thrown on reels (Sec. 227) and spun off easily as the wire is fed into the conduit. Usually a No. 14

wire is used for the lighting branch circuits although No. 12 is sometimes employed for long runs. Either single or twin conductors may be used. The use of single conductors will often be found more economical than that of the twin conductors. The single conductors will pull more readily, especially where a considerable number are to be installed in the same conduit. Also, two single-braid single conductors are usually cheaper than a twin conductor.

NOTE.—DIFFERENT COLORED BRAIDS FOR THE GROUNDED AND UNGROUNDED CONDUCTORS are used in polarity wiring (Sec. 293) as required by the new "Code." The use of braids of two colors renders polarity wiring as simple as ordinary wiring (Sec. 290). Either single or twin-marked conductors may be used, but the single conductors are usually the more convenient.

**227. Special Reels Should Be Used For Carrying The Coils Of Small Wires Which Are Being Pulled Into Conduit.**—

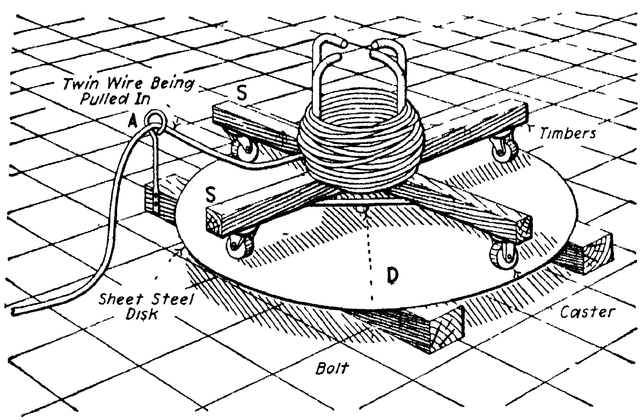



FIG. 493.—Easily-running twin-wire reel. (The two cross sticks, *S*, are fastened together at the center and rotate around a bolt on the 4 casters. The sheet-steel disc, *D*, resting on two timbers forms a smooth track for the casters. The guide arm, *A*, through which the conductors are passed, minimizes twisting and kinks.)

The reels, described later, prevent kinks and tangles from forming in the wires. They should be used wherever possible. They are particularly desirable where a number of conductors are being drawn into the same conduit. The time they save, even on short runs, more than justifies their expense. Improvised reels (Figs. 493, 494, and 495) can be

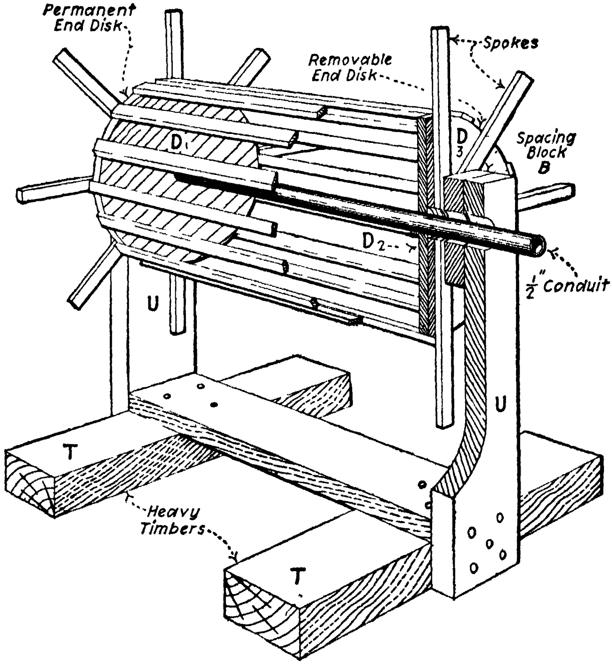



Fig. 494.—Reel for conductors which are being pulled in. (The slats, ½ in. by 1 in. by 20 in., comprising the cylindrical portion of the drum, are nailed to the two discs, $D_1$ and $D_2$, projecting over disc, $D_3$, which is removable. When mounting a coil of wire on the reel, the reel is taken from the frame, the removable disc, $D_3$, drawn out, and the coil of wire placed on the drum. The timbers, $T$, are made heavy to prevent tipping.)

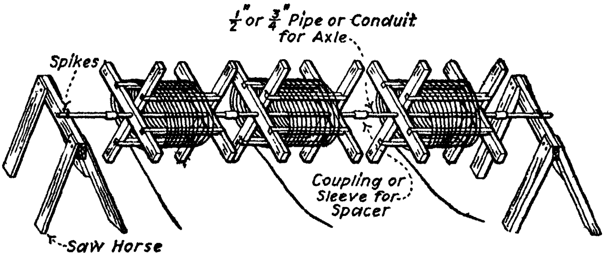



Fig. 495.—A multiple-reel arrangement used where three wires are being pulled in simultaneously. (One end wheel of each reel should be held in its reel with wood screws, so that it can be removed readily to provide for the mounting of a coil of wire.)

made at but a small cost. The details for the reel of Fig. 495 are given in Figs. 496 and 497. A commercial reel manufactured by the Wiring Equipment Co. (Fig. 498) has given very satisfactory service. It is similar in operation (Fig. 499) to the improvised reel illustrated in Fig. 493.

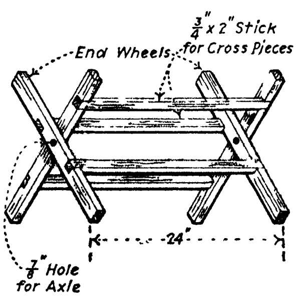



FIG. 496.—Reel unit assembled.

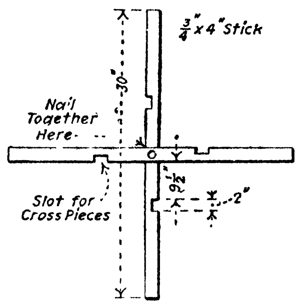



FIG. 497.—Detail of end wheel for pulling-in reel.

NOTE.—IF REELS ARE NOT USED, ONE OF TWO PROCEDURES MUST BE FOLLOWED: Either the wires must be fed from the coils laid loosely. on the floor or the length of wire necessary for the run must be wound out, laid on the floor, and cut off before being drawn into the conduit. By

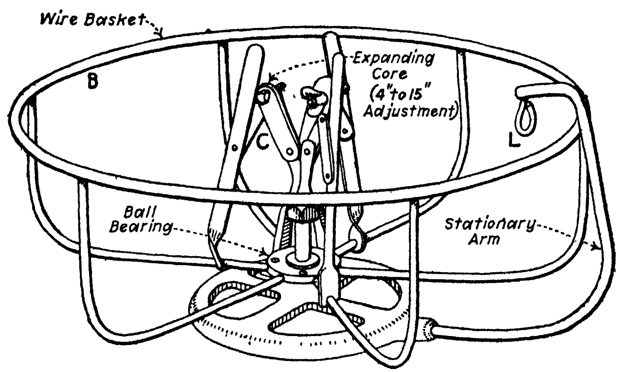



FIG. 498.—Reel made by the *Wiring Equipment Company*. (It is made in two stock sizes of 12 in. and 24 in. outside diameter.)

the former method, tangles and kinks in the wires are unavoidable and much time is lost in correcting them. In the latter method, considerable time is lost in laying out the wires and also much wire is wasted by cutting the lengths of wires too long. Both methods are wasteful, even on short runs, and should not be employed unless it is impossible to use a reel.

NOTE.—THE TYPE OF REEL SHOWN IN FIG. 493 HAS THE ADVANTAGE over those shown in Figs. 494 and 495 that the coil of wire can be placed directly on the reel without disassembling any part of the reel. In the types shown in Figs. 494 and 495 the cylindrical part must be disassembled in order to place a coil of wire on the drum. However, the reels of Figs. 494 and 495 can be used to mount several coils of wires, while the other (Fig. 493) cannot. The multiple reel arrangement (Fig. 495) is not recommended because it requires too much space and is not very rigid in construction. It is usually advisable to use one reel for the several coils (Fig. 494) or to use several separate reels.

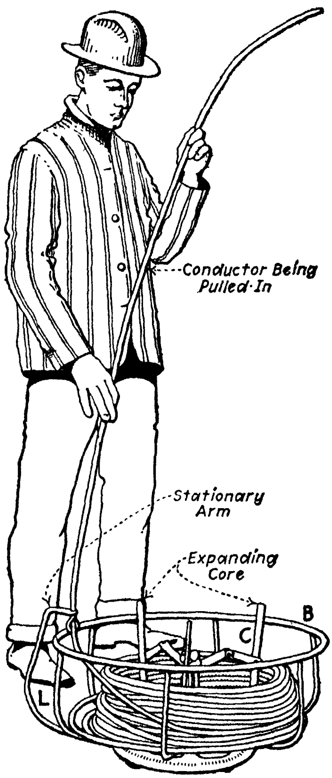



FIG. 499.—Wiring Equipment Company's reel in use.

**228. Large Feeder Conductors Can Be Handled More Economically If Ordered To The Exact Length** required for the run. The measuring and cutting of feeder cables on the job should be avoided as much as possible. The determination of proper feeder length measurements, by snaking (fishing) a conduit and then measuring the snake is not very difficult. But at the time the wire arrives on the job there is seldom a good opportunity for uncoiling the wire and measuring it. When this is done, additional reel equipment and measuring instruments are usually necessary for good results. It is usually advantageous to have all the legs of large feeders wound in parallel on one reel. This arrangement reduces handling and makes it possible to set up the reel at one point and, after the pulling-in rope or cable has been drawn through the conduit, to pull in the feeder in one operation. Thought must be given to the weight of the resulting reel, and if it

is too big to handle easily, the individual legs must be wound each on separate reels. Most wire companies will cut large cables to measurement and will accomodate the contractor's wishes in the matter of mounting the cables on reels.

NOTE.—IN SETTING UP HEAVY REELS OF CABLE, the strength of the floor construction where the reel is placed should be considered. It is preferable to place the reel over a steel beam rather than in the middle of a span of floor arch. When setting a reel in jacks, firm bases for the jacks must be provided, or some other provision made, so that the reel will not topple over.

NOTE.—AS WIRE COMPANIES CHARGE FOR THE REELS on which cables are mounted, proper attention should be given to the disposal of empty reels. They should not be thrown out for junk, but instead should be accumulated until enough of them to make up a load are obtained. Then, they may be shipped back for credit. If the lagging can be preserved, it should be nailed back in place on the reel, as it also is charged for and can in this manner be salvaged.

**229. Before Fishing Can Be Effected, Obstructions, If Any, Must Be Cleared From The Interior Of The Conduit.** It sometimes occurs, often in an inexplicable manner, that foreign matter finds its way into the interior of a conduit run. Gobs of plaster or cement thus lodged inside of the duct may cause a great deal of trouble. In reinforced concrete buildings, where the conduit installation progresses with the concrete construction, these barriers inside of the conduits are likely to be encountered. Such difficulties may be minimized if the wiremen will carefully close the ends of the conduit runs when they leave the work (Sec. 61). But even if this practice is followed, such obstructions are sometimes encountered. Obviously, before a fish wire can be pushed through a conduit the obstructions must be cleared.

**230. The Methods Of Clearing May Be Discussed Under Six General Headings,** thus: (1) *Manual clearing.* (2) *Pneumatic clearing.* (3) *Clearing by explosive percussion.* (4) *Clearing by chemical action.* (5) *Hydraulic pressure clearing.* (6) *Clearing by cutting into the conduit run.* Each of these will be treated in the subsequent sections.

**231. In The Manual Clearing Of A Conduit Run,** to free it from obstructions, a fish wire is inserted into the conduit and pushed until its end butts against the obstruction. Then the wire is worked to and fro in an effort to dislodge the obstacle.

Where the particle stuck in the duct is small and does not adhere tightly, the manual method will be satisfactory. But in general it is not very effective.

**232. In Clearing A Conduit With Compressed Air,** a force pump (Fig. 520) (which should preferably be of the design used by plumbers and gas fitters for forcing obstructions from pipe) is connected to one end of the obstructed run and the pump is operated. The pressure thus created against the obstacle tends to dislodge it. With the air pumps used by plumbers, it is possible to establish considerable pressure within the reservoir connected with the pump, and then by opening a releasing valve allow this pressure to impinge against the obstacle. The high pressure thus suddenly imposed is much more effective than a continued pressure of low intensity. An air compressor, if available, should be used as it is more desirable than the force pump.

NOTE.—THE PNEUMATIC METHOD IS EXTREMELY EFFECTIVE in clearing conduits of small readily detached particles, but it will seldom remove firmly attached obstacles. The method can be used to remove the debris from a conduit after an opening has been forced through the obstruction by some other method. This debris if allowed to remain in the run might injure the conductors.

**233. In Clearing A Conduit By Explosive Percussion** a blank cartridge is discharged through the offending conduit.

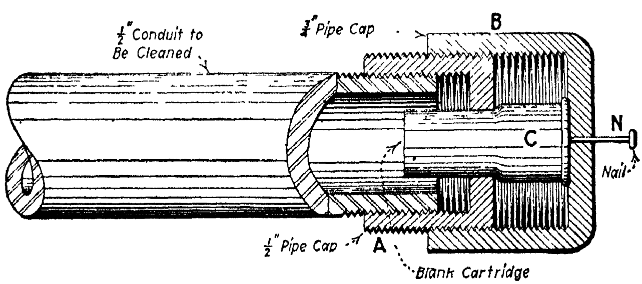



FIG. 500.—"Gun" for shooting obstructions from ½-in. conduit.

This method owes its effectiveness to the suddenly imposed impulse caused by the explosion which tends to break the bond between the obstruction and the walls of the conduit. In Figs. 500 and 501 are shown the details of an improvised "gun," which is attached to one end of the obstructed conduit,

whereby the cartridge is discharged through the conduit. In order that the gun be assembled tightly, it is desirable to "square off" the edge of the faces of the caps, *A* and *B*. For conduits of the smaller diameters, where the length of run is short, a 0.22 caliber cartridge is ordinarily ample, but for conduits of the larger diameters or where the conduit run is long, bigger cartridges up to possibly 0.44 caliber may be used. To clean a ½-in. conduit with this gun, the device is assembled on the end of the conduit (Fig. 500) with the cartridge in position. For a ¾-in. conduit the gun is mounted as shown in Fig. 501. The cartridge is discharged by striking the nail firing pin, *N*, a smart blow with a hammer. The conduit serves as a barrel for the piece. It is imperative, to insure safety, that the workman remain out of line with the pipe cap end of the gun when it is being fired, as the effect of each shot until the conduit is cleared, is dissipated largely by a discharge through the firing pin hole.

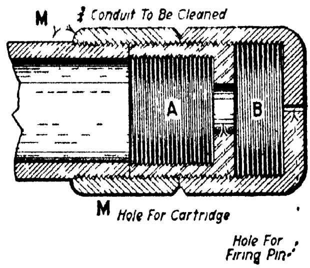


FIG. 501.—Gun for shooting ¾-in. conduit.

NOTE.—THE PERFORMANCE OF THE CONDUIT CLEARING GUN may be gaged from the following case which was reported by Mr. Ismond. In one installation a run of 300 ft. of conduit having in it two 90-deg. elbows was cleared with two shots. The first shot, which apparently loosened the principal obstruction, discharged portions of chips, corks, rag, and plaster. The second shot forced out a hunk of concrete which about half filled the tube.

**234. Clearing Conduit Runs By Chemical Action** is a method which is not to be generally recommended, although it has been used with apparently good results in certain instances. With this method, some acid solution which will dissolve or loosen the plaster or cement, which has accumulated inside, is forced into the conduit. Vinegar in one instance was used for this purpose and it dissolved in twelve hours an obstruction which defied other methods. A dilute solution of hydrochloric acid may also be used. The objection to the method is that the acid solution may have some deleterious affect on the

interior surfaces of the conduit, the extent of which it is difficult or impossible to ascertain. Care should be taken that the acid is sufficiently dilute that it will not affect the conduit.

**235. The Hydraulic-Pressure Method Of Clearing Conduit** consists in forcing, with a suitable pump (for example, a hydraulic force pump like that used by plumbers or for gage testing), water under pressure into the conduit against the obstruction. By this means relatively enormous pressures can be exerted. It might be desirable, in certain instances, to force acidulated water into the conduit so that the combined effects of hydraulic pressure and chemical action might be utilized. This method also has the objection that it tends to leave water inside of the duct which may subsequently cause trouble. However, practically all of this moisture may be driven out of the conduit by forcing the water from it with a force pump and continuing the action of the pump until the interior of the conduit becomes practically dry. To thus dry the conduit, a vacuum cleaner may be employed to advantage, for either drawing or forcing a current of air through the conduit. The method shown and described in Sec. 277 may also be used.

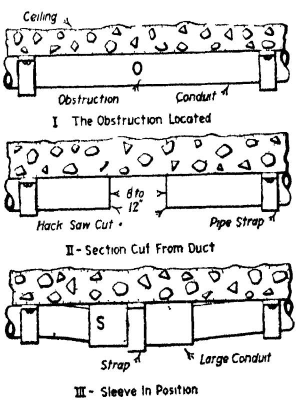



FIG. 502.—Method of opening and repairing choked conduit to remove obstruction.

NOTE.—WHEN CONDUIT INTERIORS BECOME CLOGGED WITH ICE during the construction of a building, a steam hose can be connected to the end of the conduit, whereby the ice is melted, or hot water can be forced in with a pump as suggested above. Where either of these methods is employed, the conduit interior should, as specified, be carefully dried with an air current to insure against future trouble.

**236. In Cutting Into A Conduit Run To Remove An Obstruction** the method suggested in Fig. 502 can, if the run is exposed, be followed. At *I* the obstruction, *O*, is shown within the conduit. Its location in the conduit can be determined by inserting a fish wire from the nearest outlet to the obstruction, measuring the length of fish wire thus inserted and laying it

off along the route of the run. After the point of obstruction has been thus located the conduit is cut through, as shown at *II*, with a hacksaw at a distance of 4 to 6 in. on each side of the obstruction. Then this section of conduit is taken out and it should contain the material which caused the clog. To repair the break, sleeve, *S*, which will fit snugly over the original conduit is cut, placed and secured in position at the point of the break, as shown at *III*.

**237. Fishing Methods May Be Classified Into Three General Divisions,** as follows: (1) *Manual wire fishing* (Fig. 503). (2) *Pneumatic fishing* (Fig. 520). (3) *Machine fishing* (Fig. 528). In manual wire fishing, a steel wire or ribbon is forced by hand through the conduit from one conduit case to another In pneumatic fishing, a fish line is forced with air pressure through the conduit from one conduit case to another. In both these methods, the conductors or the heavy pulling-in lines (if the runs are difficult to pull in) are manually drawn into the conduit by the fish wire. The pulling-in line (if used) is then employed to draw in the conductors. In machine fishing (Fig. 528), a flexible spring-steel ribbon is impelled through the conduit run by a specially designed machine. Then the conductors or a pulling-in line can be drawn into the conduit as the machine winds back the tape.

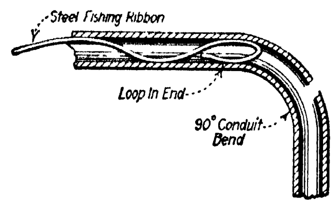


FIG. 503.—Fishing ribbon buckled in conduit at a 90-deg. bend.

NOTE.—HEAVY RUNS SHOULD NOT BE PULLED INTO THE CONDUIT WITH THE FISH RIBBON because such a treatment will tend to abstract the "life" from the steel. Although the steel ribbons used for fishing are very strong (considering their cross-sectional areas) and will sustain a surprisingly large stress without rupture, they will lose their "springiness" and hence be valueless if they are strained beyond the elastic limit. Experience has shown that this elastic limit can be exceeded more readily than is usually believed. However, as the fish ribbon is cheap compared to labor costs, it is often economical to pull in runs with the ribbon and use a new one when necessary than to spend the additional time required for attaching a pulling-in line and drawing it through.

**238. The Kind Of Wire To Use For Manual Wire Fishing** depends somewhat on conditions. Ordinary No. 12 or 14 round galvanized steel wire (often incorrectly called galvanized iron wire) can be used for fishing short runs. For long runs, or runs where it is desirable to employ the fishing wire as a pulling-in line for relatively large conductors, No. 10 galvanized steel wire can be employed. These wires can be obtained at most hardware stores or electrical supply houses. For most effective fishing, a spring-steel ribbon or tape about ¼ in. wide and 0.03 in. thick is desirable. Due to the high temper and springiness of these tapes, they can be shoved a greater distance, without kinking, than can the galvanized steel wire. Hence, with them, less time is required for fishing. These steel fish ribbons can be obtained in lengths up to about 200 ft., but a length of 50 ft. is most suitable for average use. The dimensions of the different sizes of fish tapes or ribbons are given in the author's "American Electricians' Handbook"; hence they will not be repeated herein. Information relating to wire fishing in old buildings is given in the author's "Wiring Of Finished Buildings."

NOTE.—A TWISTED GALVANIZED STEEL WIRE is well suited for fishing conduit. A piece of ordinary galvanized steel wire, about twice the length of the desired fishing snake, is taken and doubled back in the middle. A large spike is placed in the middle of the length where the wire is doubled back and the wire and spike held in a vise. The two loose ends of the wire are then clamped in the chuck of a brace and, by means of the latter, twisted tightly to resemble any twisted pair or lamp cord. The twisted pair is much stiffer than fish tape, but it is sufficiently flexible for fishing. It has, for certain conditions, been found better than ordinary fish tape because it remains straighter and does not coil or snarl up as readily as does the fish tape.

**239. Strips Of Rattan Are Sometimes Used For Fishing** large-diameter conduits. The Brooklyn Edison Company has used lengths of rattan spliced together so as to form a reed 30 or 40 ft. long. This reed is used for fishing conduits from poles down into manholes and for fishing service pipes into buildings. These rattan fishing reeds are obviously applicable for only relatively short runs, say for 50 to 60 ft. where the diameter of the orifice is about 2 in. or greater. A ball, turned from wood and fixed on one end of the reed,

insures that that end (the one which is first inserted in the conduit) will pass with minimum resistance through couplings and past the joints between conduits.

Note.—Chain May Be Used For Fishing Vertical Runs (Sec. 266). A small chain can be made to drop down a vertical conduit with little difficulty. When in a partition, the noise made by the lower end of the chain as it is jiggled up and down will disclose its location almost exactly.

**240. The Contour And Arrangement Of Conduit Runs** (Figs. 504 and 505) affect the cost of fishing and the time

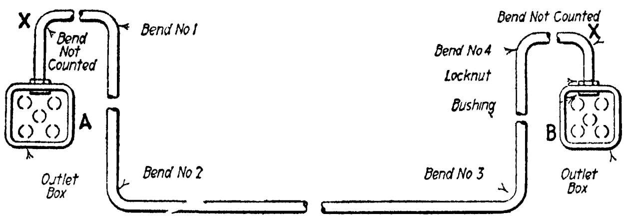



Fig. 504.—Conduit run containing four "effective" bends and for which no pull box is necessary.

required therefor. Every offset or turn introduced between conduit cases in a conduit run increases materially the difficulty of fishing that run. A run 100 ft. long without any turns or

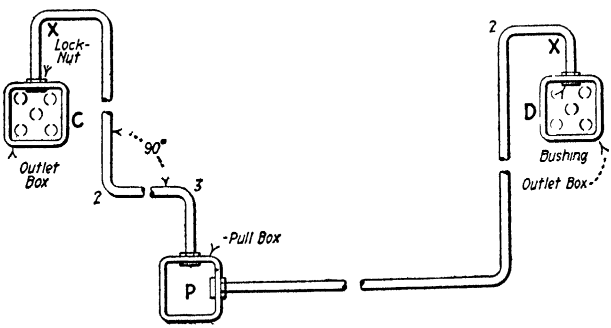



Fig. 505.—Conduit run which would have six "effective" bends between outlets if the pull box were not inserted.

offsets can be fished very readily with a good fishing ribbon, but a run 15 ft. long containing a number of offsets and turns may be difficult or even impossible to fish. When an endeavor is made to fish a conduit run which contains a large number

of bends, the fish wire buckles at one of the elbows (Fig. 503) instead of passing around it. Since there are a number of other turns between the elbow which is causing the trouble and the outlet from which the fish wire is being forced, it is impossible to exert a maximum longitudinal pressure on the fish wire by pushing on it where it enters the conduit.

**241. Furthermore, It Is Very Tedious To Pull Conductors Into A Run Which Contains A Number Of Bends.**—Every bend introduced in a run between conduit cases means that just that much more stress must be imposed upon the conductors in pulling them in With a large number of bends, such a stress may become so excessive that the conductors may be strained and weakened. Therefore, their cross-sectional areas may be uniformly, or only at weak points, materially reduced. Such reduction of section tends to cause local overheating of the conductor in the conduit when it is carrying current. It is for these reasons that the number of bends between conduit cases is limited by the "National Electrical Code."

NOTE.—THERE SHOULD NOT BE MORE THAN THE EQUIVALENT OF FOUR 90-DEG. BENDS BETWEEN CONDUIT CASES. In "Code" Rule 503*f* it is stated that a conduit run "*must have not more than the equivalent of four quarter bends (right-angle bends) from outlet to outlet, the bends at the outlets not being counted.*" The term "outlet" as used in Rule 503*f* of the "Code" means any place where access to the interior of the conduit system is provided. Thus it is any place where a conduit case is installed. In this text the term "conduit case" will be employed to convey this meaning instead of the term "outlet" because the term "outlet" is reserved to mean only locations where energy-consuming, switching, or controlling devices are installed (Sec. 31). Hence, there is allowed, not counting the bends at the conduit cases, a 360-deg. change in direction of the conduit run between conduit cases. In Fig. 504 is diagrammed a run between the outlet boxes *A* and *B* which contains the maximum number of 90-deg. bends—that is, four—between conduit cases. Bends *X* and *X* near the outlet boxes are not counted. With the run shown in Fig. 505 there would be, were it not for the insertion of the pull box, *P*, six effective bends between the outlet boxes (conduit cases), but with the insertion of the pull box, which is itself a conduit case, there are only two effective bends between *P* and *D* and three effective bends between *C* and *P*.

**242. Manual Wire Fishing May Be Treated Under Two General Classifications:** (1) One-way fishing. (2) Two-way

fishing. One-way fishing is that where but one fish wire is used and it is manipulated or pushed entirely through from only one end or outlet of the conduit run. Two-way fishing is that for which two fish wires, one pushed in from each conduit case of the conduit run, are utilized. The two wires are then manipulated until their hooked ends engage (Fig. 506) somewhere inside of the conduit, after which one of the wires is pulled through by the other.

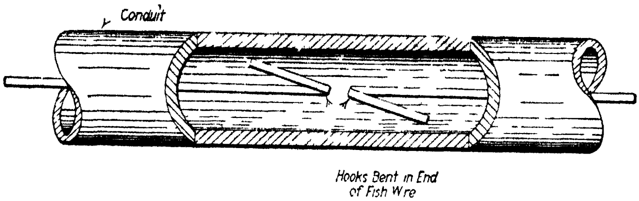



FIG. 506.—Showing method of bending fish wire ends to insure engagement.

**243. Fish Wire Ends Must Be Rounded** in some way or other if most effective work is to be done. If the square end of a ribbon or a round wire is forced into a conduit, such an end is liable to foul against the end of a conduit inside of a coupling. The ends of the conduits should be reamed to a bevel inside and should be screwed together in the couplings until they butt. This would minimize the possibility of

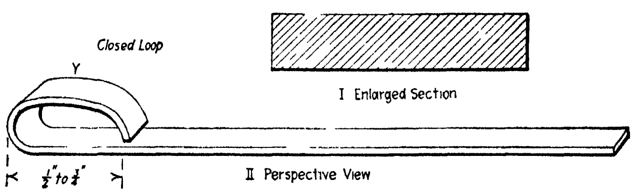



FIG. 507.—Loop formed in end of steel ribbon wire used for fishing conduit.

fouling. However, in practice, the ends do not always butt, which results in the condition just described. Hence, the end of every ribbon fish wire should be rounded in some manner. The usual method is to form a closed loop on one end (Fig. 507). Such a loop will not only slide over the joints between conduit lengths, but it will also permit the ribbon to be forced more easily around elbows. Furthermore, the loop provides an eye whereby the conductors to be pulled in

(or the pulling-in line) can be attached to the ribbon. The loop should be about ½ to ¾ in. long.

NOTE.—THE PROCESS OF BENDING THE LOOP IN THE FISH RIBBON END is not generally understood. A good fish ribbon is made of tempered steel and it must be treated accordingly. Hence, to bend the loop in the end, it should be heated to a red heat, bent and then slowly cooled. Unless a proper bending method is followed, the steel will loose its temper and the eye bent in its end may pull open or be forced open when stress is imposed upon it.

NOTE.—THE GALVANIZED STEEL WIRE IS BENT while cold. As the wire is not tempered, it need not be heated for bending as is desirable for the tempered fish ribbon.

**244. A Loop And Ball Fish Wire End** (Fig. 508) is a variation from the common design. A lead ball is cast on the end of the wire. This insures its easy passage through the

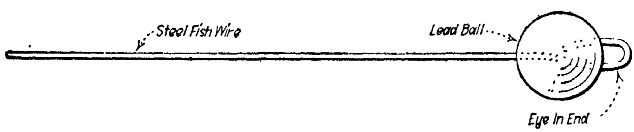



FIG. 508.—Lead ball cast around loop in fish-wire end.

conduit. The ball is formed around a loop in the wire. Thus, an eye is provided to which conductors to be pulled in, or a pulling-in line, can be attached. Furthermore, loops of cord, as described in Sec. 247 and as used in double-end fishing, can be tied in the loop at the end of the ball. Some wiremen always twist a "longitudinal quarter turn" in the ribbon wire about 2 in. from the ball at its end. That is, they twist the ribbon through an angle of 90 deg. This, it is claimed, tends to permit the wire to pass more readily through the conduit.

NOTE.—SMALL BRASS BALLS OR KNOBS are often riveted on the ends of steel fishing ribbons. Details of these balls or knobs are given in the author's "American Electricians' Handbook." Fishing lines provided with such balls are easier to fish than those which have hooks formed on their ends. The balls are particularly desirable where flexible metallic conduit is to be fished.

**245. A Long-Radius Curl In The End Of A Fish Wire** (Fig. 509) facilitates fishing to conduit boxes. Where the fishing ribbon as ordinarily prepared is used for fishing to a ceiling outlet, the end $E$ (Fig. 509) is often blocked against the side

of the conduit box. Then a ladder must be obtained to disengage the ribbon or it must be drawn down from the ceiling

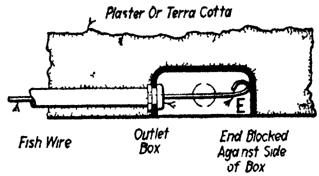



FIG 509 —End of fish wire blocked against side of outlet box.

with a hook of some sort. If a long-radius curl (Fig. 510) is first bent in the wire it will then, when its end comes out of a

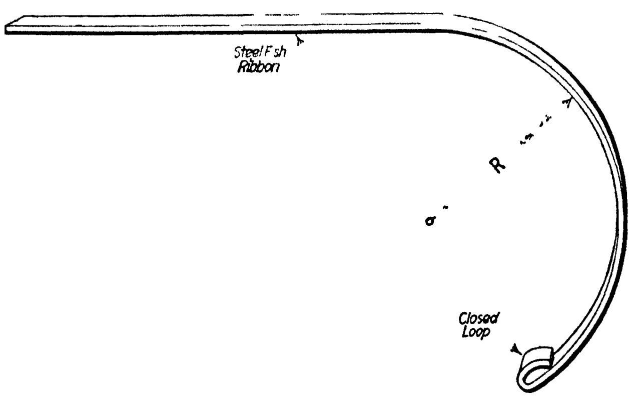



FIG 510 —Semi-circular end bent in loop for fishing to ceiling outlet boxes.

conduit box, tend to curl down and out of the box (Fig. 511). Thus, the interference of Fig. 509 will not occur.

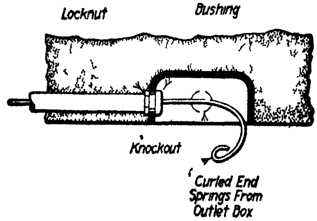



FIG 511 —Fish wire having curled end works out of outlet box.

NOTE.—A GUIDE TUBE MAY BE USED ADVANTAGEOUSLY IN FISHING FROM CONDUIT BOXES (Fig 512). The tube, *T*, may consist of a piece, say

2 or 3 ft. long, of lead pipe, or of tin tubing such as is used in connecting bar or soda-foundation fixtures. It is necessary that the tube be of a ductile material so that it can be formed readily into the contour required. A guide tube thus used as two advantages: (1) It prevents the kinking of the fish ribbon in the conduit box, thereby forcing the ribbon directly into the conduit. (2) Where wall outlets are located so high above the floor that a ladder would ordinarily be necessary to reach them, the guide tube can, when fishing, be inserted into the conduit which enters the outlet box by reaching up from the floor The use of a ladder is thereby rendered unnecessary. The tubing, where thus used, will guide the ribbon squarely into the conduit.

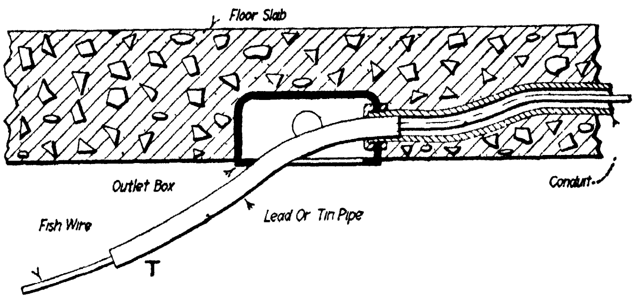



FIG 512.—Lead pipe guide tube for fish wire. The fish wire is pushed in through $T$.

**246. Fish Wires May Be Lubricated,** where long and difficult runs are to be fished. The proper lubrication permits the fish wire end to slide much more readily through the conduit. It thus renders possible the fishing of longer runs with less effort. The disadvantage of lubricating fish wires is that most lubricants which will adhere to the fish wire will also attack the rubber insulation on the conductors. Oils and greases are particularly objectionable and should never be used, since they in time will decompose the rubber insulation. However, kerosene, since it evaporates readily, may be employed if used sparingly and carefully. Paraffin is a good fish-wire lubricant as it does not attack rubber and is also a good insulator. Care should be taken not to use it in runs which are liable to heat, because the paraffin is easily melted and the hot paraffin is injurious to the rubber insulation; furthermore it may cement the conductors to the interior tube walls.

NOTE.—TO LUBRICATE A FISH WIRE with kerosene, it may be wiped as it is passed into the conduit with a small rag which is saturated with the kerosene. To lubricate the wire with paraffin, its forward end is rubbed on all sides with a piece of the wax, and the remainder of the wire can be similarly treated as it is forced into the conduit.

**247. In Two-Way Or Double-End Fishing** a hook must be bent at the working end of each wire, or a hook can be bent in the end of one wire and a loop or eye in the end of the other. Similar devices can be adopted whereby the ends of the two wires can be forced to engage within the conduit. In one method (Fig. 506), which has been used successfully, each of


FIG 513—Another method of bending fish-wire ends for two-way fishing

the fish-wire ends has a hook at its end but the free portion of the ribbon is bent sideways at an angle to the main line. Where hooks are formed thus, the snakes will engage or "hook

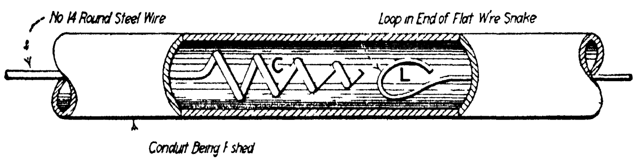



FIG 514—Fishing with end of round steel wire bent into corkscrew form.

together" more readily than they would otherwise. A method in which a hook *H* (Fig. 513), is bent in the end of one wire and an eye, *E*, in the end of the other is sometimes successful where others fail. In another scheme (Fig. 514), which has

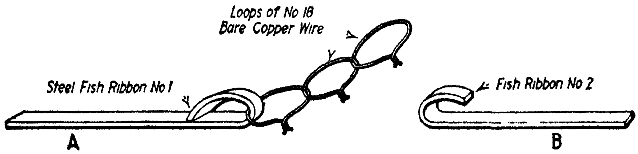



FIG. 515.—Copper-wire loops in fish wire end to promote ready engagement.

been applied successfully in certain cases, one snake is a No. 14 round galvanized steel wire and the other is a steel ribbon. The end of the steel wire is formed into a corkscrew as shown at *C* and the end of the ribbon into a loop or eye, *L*. After

the two wires have been forced together within the conduit, the round steel wire is twisted and pushed forward so that its corkscrew turns will engage in the loop *L*. Then both of the wires can be pulled out of the conduit by drawing on either one of them.

NOTE.—LOOPS TIED IN FISH WIRE ENDS (Figs. 515, 516, and 517) are often effective in two-way fishing. In Fig. 515 the loops consist of lengths of No. 18 bare copper wire bent and twisted so as to form a chain. These are attached to an eye bent in the end of one fish wire, *A*. The end of the other fish wire, *B*, is formed into a hook. When the two fish wires thus prepared are forced together within the conduit and one of them is turned and pulled to and fro, an engagement can usually be made.

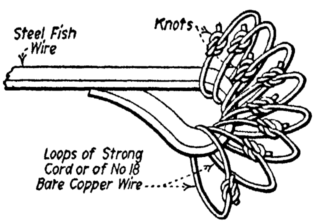



FIG. 516.—Another, but undesirable, method of arranging loops in fish-wire end.

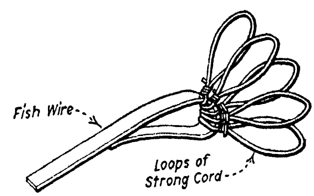



FIG. 517.—Cord loops tied on end of fish wire for two-way fishing.

Loops of cord instead of wire are sometimes used. These may be tied in the eye as shown in Fig. 516; each loop being separate and distinct. However, another method (Fig. 517) wherein one continuous length of cord is formed into a number of loops in the eye, is often preferable. In drawing from the conduit two fish wires, which have been used for two-way fishing, it is customary to pull out on the shorter wire which is engaged with the longer one. Simultaneously a helper should feed the longer one into the conduit at the other conduit case so that the pulling stress on the short wire will not be excessive.

**248. The Fishing Of A Large Conduit With A Smaller Jointed Tube** is disclosed in Fig. 518. This method is applicable only for large-diameter conduits where the greater part of the run is straight. That is, the distance *L* (Fig. 518) should be for its greatest length except at its extremity, straight. The method consists in pushing through an elbow fitting, *F*, which is located at one end of the run to be fished, a jointed length of ½-in. conduit. Sufficient lengths are screwed together successively as this "rod" is forced into the conduit.

Hooked over the far end of the jointed tube thus inserted, is a length of No. 14 rubber insulated wire which is carried into the duct as the pushing proceeds. After the jointed tube has been forced into the conduit as far as a bend, a steel fish wire with a hook on its end is pushed down from the other end of the run *E*. It is then manipulated until it engages with the loop of No. 14 wire, whereby the No. 14 conductor is pulled through. The No. 14 wire then serves as a pulling-in line.

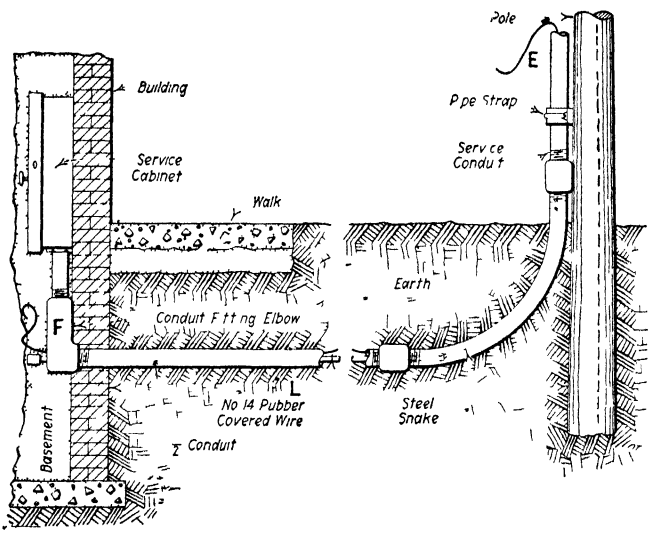



FIG. 518 —Fishing large conduit with small pipe or tubing.

Lengths of ½-in. conduit which have been prepared for the long-distance boring tool described in the author's "Wiring of Finished Buildings" may be used for rodding by the method just described.

**249. In Fishing Wires Through Fixtures** a lead weight on the end of a cord is, ordinarily, the arrangement used. The fixture tube can be held in an approximately vertical position while the fishing is being done so that the weight will be pulled through by gravity. Such a weight is called a *mouse*. A number of different designs of this tool and its applications are described in the author's "Wiring of Finished Buildings."

**250. To Straighten A Fish Wire Or Ribbon** a device similar to that illustrated in Fig. 519 may be used. After any fish wire has been in service for some time it becomes "kinked." Short kinks in the wire interfere with its progress inside of the conduit. The straightening arrangement (Fig. 519) consists of a wooden block, *B*, into which nails, *N* and *N*, are driven. At one end of the block is a double-pointed tack, *T*, through which the wire to be straightened, *W*, is threaded. The nails are driven in two parallel rows somewhat out of line with each other. The distance between these rows is

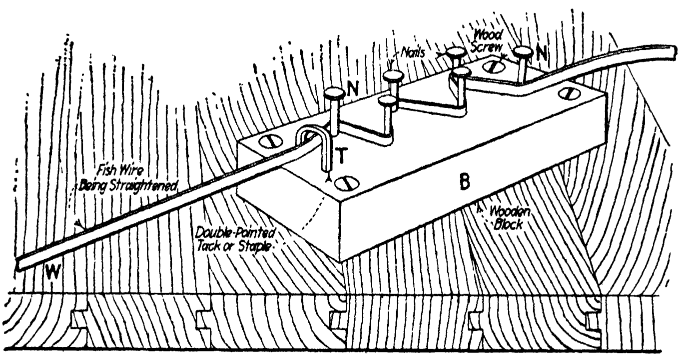



Fig. 519.—Arrangement for straightening fish wire.

exaggerated in Fig. 519 in order better to illustrate the principle. For steel fish wire or ribbon, the distance between centers of rows need not ordinarily be much greater than the width of the ribbon or the diameter of the fish wire.

Note.—To Straighten The Wire, *W*, It Is Merely Pulled For Its Entire Length around all of the nails through the eye, *T*. Considerable force is imposed on the block, *B*, while the wire is being pulled. Hence, it is desirable to hold it securely in a vice or with screws to the top of a bench or some other stationary object. To grip the fish wire end in pulling it through, a hand vise or a *come-along* (Fig. 558) such as is used for pulling up line conductors, should be clamped on the wire. One of these tools insures a firm grip for the man who is doing the pulling. The helper should be stationed back of the block to feed the wire to it as it is withdrawn from the other end.

**251. Pneumatic Fishing May Be Treated Under Two General Classifications**: (1) *Pressure or plenum fishing.* (2) *Vacuum fishing.* Pressure or plenum fishing is that where a

piston, to which a fish line is attached, is impelled or forced through the conduit run by an excess air pressure which is created behind it. The pressure is established by a force pump. Vacuum fishing is that where the piston (to which a fish line is fastened) is pulled or "sucked" through the conduit by a partial vacuum created at the far conduit case, by a suitable vacuum pump.

**252. The Principle Of Pneumatic Pressure Fishing** may be understood from a consideration of Fig. 520. The air

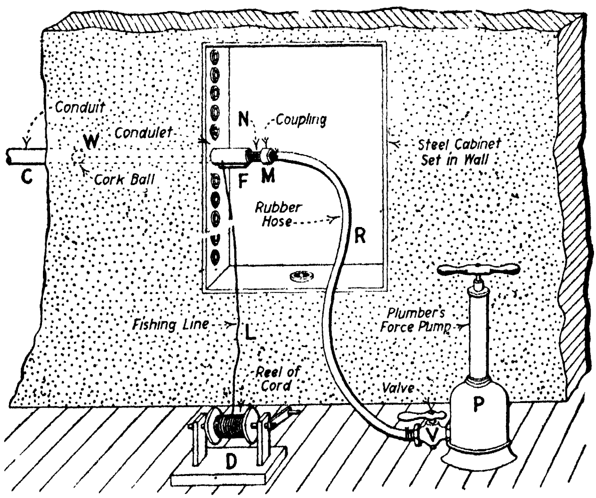



FIG. 520.—Showing application of "cord-feeding fitting" at *F*.

pressure is created by the pump, *P*, which is connected with the rubber hose, *R*, to the conduit, *C*, which is being fished. Due to the pressure developed by *P*, a piston, *W*, which fits loosely within the conduit (and to which the fishing line, *L*, is attached) is forced through the conduit from one conduit case to another.

NOTE.—AN IMPORTANT ADVANTAGE OF THE PNEUMATIC FISHING METHOD IS THAT IT CLEANS THE CONDUIT OF MINOR OBSTRUCTIONS. Chips, particles of dirt, plastering, pieces of cord, and even brads and nails somehow or other get into the conduits in buildings under construction. These particles may, unless removed, obstruct the conductors which are being pulled into the conduit. Where the pneumatic method of fishing is employed, these small particles are blown out at the same time

the fishing cord is forced through. This method is also advantageous for large-sized conduit where it is difficult to fish through a fish ribbon because of its tendency to curl up in the large-sized tube.

**253. The Piston** is preferably a cork ball, *B* (Fig. 521), which has a hole through it to provide for the attachment of

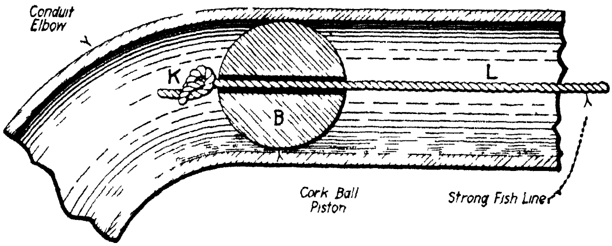



FIG. 521.—Cork-ball piston on end of fish line for pneumatic fishing

the fishing line, *L*. Or it may, in an emergency, be a wad of rag, *W* (Fig. 522). Where a cork ball is used, its diameter should be such that it will just pass readily through the straight conduit and around elbows. Before forcing such a ball piston through an actual conduit run, it should first be

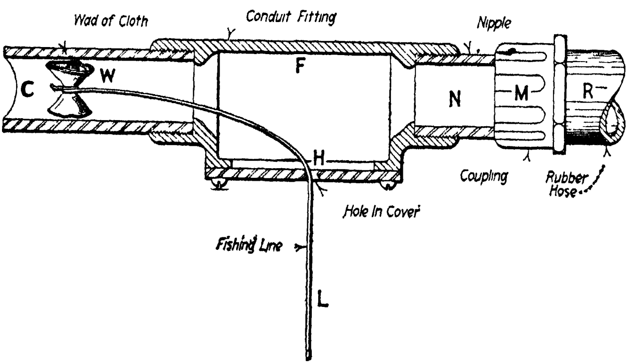



FIG. 522.—Details of "cord-feeding fitting."

pulled through an elbow held in the hand to insure that it will pass.

NOTE.—SUCH A BALL CAN BE WHITTLED FROM A LARGE CORK (Fig. 521) with a very sharp knife. However, a much better and smoother product can be produced on a high-speed lathe. The hole, through the center for the cord, should be burned with a piece of red-hot wire of

proper diameter. A knot, *K*, tied in the end of the fish line will insure its attachment to the ball. This knot, *K*, should have no long loose ends because if it has they may catch in joints in the conduit and interfere with the operation of the device.

**254. The Cord For The Fishing Line** for pressure fishing should be of the strongest material available. The best cord for this purpose is a high-grade angling line which may be purchased at a sporting goods store. If an angling line cannot be obtained, a chalk line such as is used by masons and carpenters can be utilized as a substitute.

NOTE.—WHERE THE RUN IS SHORT, A LINE SUFFICIENTLY HEAVY so that it may be used for a pulling-in line for the conductors can sometimes be forced through the conduit. But where the run is long and has many turns, it does not pay to endeavor to force through a heavy line with a force pump. In such cases, a light but very strong line should be impelled through and then, with this, a stronger pulling-in line can be drawn in.

**255. An Improvised Outfit For Pressure Fishing** is detailed in Figs. 520, 522, and 523. The pump, *P* (Fig. 520), is a plumber's force pump of the type regularly sold by plumbing supply houses. The enlarged cylindrical portion at the base constitutes a reservoir so that a considerable pressure may be developed before the valve, *V*, is opened. The rubber hose, *R* (Figs. 520 and 522), has on its upper end a coupling, *M*, which screws on a nipple, *N*, connecting it to the "cord-feeding fitting," *F* (Fig. 522). This fitting is a conduit fitting through the metal cover of which a small hole, *H* (Fig. 522), is drilled to provide for the admission of the fishing line, *L*. The nipple, *N*, is screwed into one end of *F* so that the coupling, *M*, on the end of the pump hose can be attached. The wad of cloth, *W*, on the end of the fishing line, in this case, constitutes the piston (a cork ball, *B*, Fig. 521, would be preferable). The conduit to be fished is denoted by the letter, *C*.

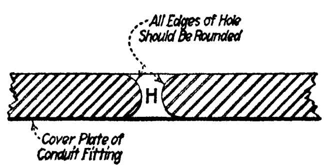



FIG. 523.—Showing how edges of hole through cover plate should be rounded off.

NOTE.—IN USING A PNEUMATIC PRESSURE FISHING OUTFIT (Fig. 520) **the first step is to screw the cord-feeding fitting, *F* (without its cover being in place), on to the end of the conduit to be fished and to connect to it the**

pressure hose, *R*. Then the fishing line, *L*, is passed through the hole, *H*, in the cover plate. The piston, *W*, is attached and pushed in the conduit and the cover plate is fastened to the fitting. Then sufficient cord to extend entirely through the run is pulled from the reel, *D* (Fig. 520), and laid in loose coils upon the floor. Valve *V* is closed and the handle of the pump is operated until a reasonably high pressure has been developed in the reservoir. Now valve *V* is opened and if things are operating properly, the piston, *W*, should be forced entirely through the run from one conduit case to another and will carry the fishing line, *L*, with it.

NOTE.—WITH THE FISHING LINE, A PULLING-IN LINE CAN BE DRAWN THROUGH THE CONDUIT. The reel, *D* (Fig. 520), is used to wind up the cord when it is not in use, in order to prevent tangling and breaking of the line.

**256. The Pressure Fishing Outfit May Be Used Without The Cord-Feeding Fitting** (Fig. 524).—In this method

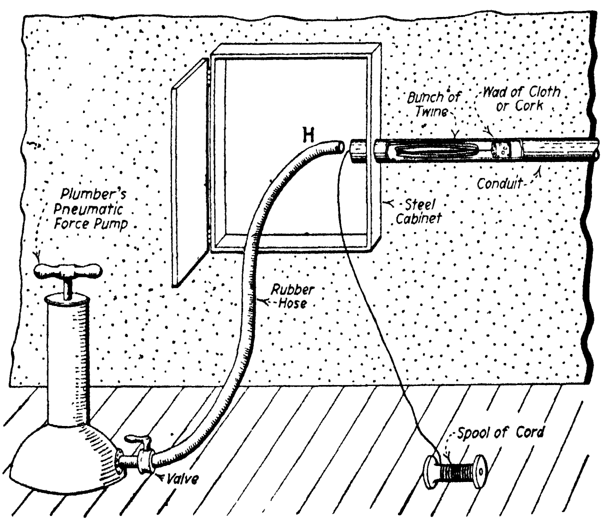



FIG. 524.—Pneumatic fishing with plumber's force pump.

instead of the fishing line being mounted on a reel and from there being pulled into the conduit, enough of it to extend from one conduit case to the next is initially placed in the end of the conduit (Fig. 524). When the hose, *H*, is placed against the end of the conduit and the pressure from the pump

released, the piston will, under favorable conditions, be forced through the conduit and will carry the fishing line with it.

NOTE —THE DISADVANTAGES OF THE METHOD WHICH DOES NOT EMPLOY THE CORD-FEEDING FITTING ARE: (1) *There is considerable air leakage where the hose is placed against the conduit.* (2) *The coils of cord placed within the conduit sometimes tangle and knot,* preventing the effective fishing of the conduit. To obviate the tangling of the cord, a round hole can be burned, with a red hot needle or wire, in the upper end of the hose (*H*, Fig. 524) to provide for the admission of the fishing line. Where this is done, the hole thus burned performs the same function as the hole, *H* (Fig 522). However, considerable friction, which retards the free passage of the cord through the conduit, is developed at the hole in the rubber through which the cord passes. It is for this reason that the practically frictionless hole in a metal cover (Figs. 522 and 523) is preferable.

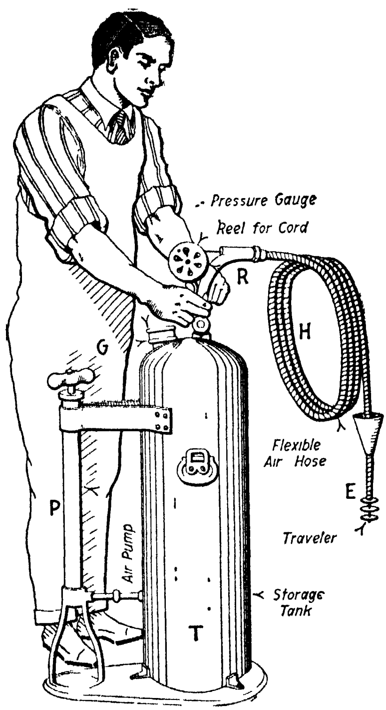



FIG. 525.—Air-pressure fishing outfit made by the *Pneumatic Conduit Threader Company, Richmond, Va.*

**257. The Pneumatic Fishing Apparatus Manufactured By The Pneumatic Conduit Threader Company** of 12 N. 8th Street, Richmond, Va. (Fig. 525), utilizes the principles of the improvised outfit (Fig. 520). The pressure-developing rig consists of an air pump, *P* (Fig. 525), a storage tank, *T*, and a pressure gage, *G*. A flexible air hose, *H*, is furnished which is inserted in the end of the conduit to be fished. The fishing cord winds on a reel, *R*. On the end of the fishing cord is the traveler, *E* (Figs. 525 and 526). This traveler consists of three thin discs or pistons mounted on a small longitudinal shaft and provided with a snap hook whereby the traveler can be attached to the eye in

the end of the fishing line. The general method of using this outfit is similar to that described in connection with Fig. 520. The outfit weighs 40 lb.

NOTE.—IT IS CLAIMED THAT THE STRONG-CORD FISHING LINE, which is provided with the outfit, is strong enough for drawing in ordinary

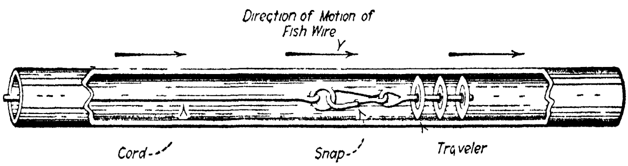



FIG. 526.—Pneumatically-impelled traveler pulling fishing cord.

conductors. Where large conductors or cables are to be handled, a pulling-in wire or line is first drawn into the conduit (Fig. 527) with the cord fish line. Runs having a length of 150 ft. and containing 7 elbows have, so it is claimed, been fished with this outfit in a few seconds.

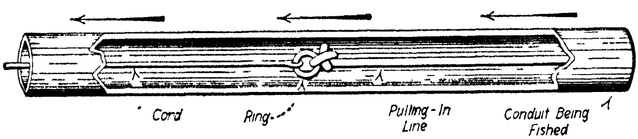



FIG. 527.—Pulling-in line being drawn into conduit with cord.

**258. Pneumatic Vacuum Fishing** is not as effective as pressure fishing but may often be employed to advantage where no pressure pump is available but a *vacuum cleaner* is at hand. The suction hose of the cleaner is placed over one end of the conduit to be fished and the fishing line, having on its end a cloth wad or a cork piston, is fed into the other conduit case. The vacuum produced by the cleaner pump will pull the line through ordinary runs.

NOTE.—THE REASON THAT THE PLENUM METHOD IS THE BETTER is that with a good force pump and reservoir a very high pressure can be produced. The production of an equivalent pressure difference is not possible with the ordinary vacuum pumps. Then, too, the conduit system will not maintain a high vacuum as well as it will a pressure because the vacuum is more difficult to "hold."

**259. Conduit Fishing Machines** which forcibly impel a fishing ribbon through the conduits have been used in certain

cases There is only one which was, to the writer's knowledge, regularly manufactured This (Fig 528) was the National Conduit Fishing Machine It was manufactured by The National Conduit Wiring Company, 25 Broad Street, New York City, but apparently this concern is no longer in business

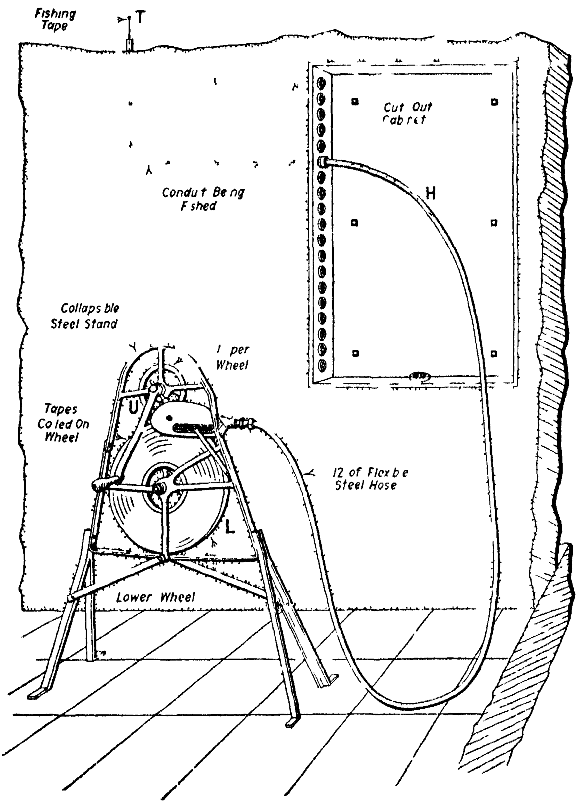



FIG 528 —Showing application of the National Conduit Fishing Machine

**260. The Principle Of The National Fishing Machine,** which is patented, is illustrated in Fig. 529. It involves the winding of two steel tapes, *T* and *B*. The tape, *T*, constitutes the fish wire and is forced through the conduit. The tape *B* is the winding tape. Both of these tapes are first wound on the lower spool, *L*. Tape *B*, which is fastened on the upper spool, *U*, acts as a driving pulley and forces *T* out through the

flexible armored hose, *H* (Fig. 528), and into the conduit which is to be fished. The hose guides the tape from the machine to the conduit outlet.

Note.—The Operation Of The National Machine may be described thus: The hose, *H* (Fig. 528), is first thrust into the end of the conduit

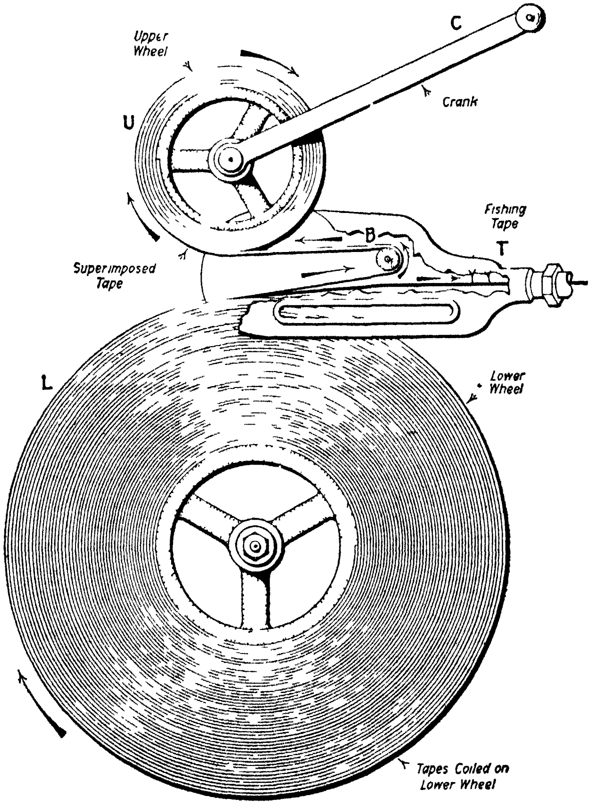



Fig. 529.—Illustrating the operating principle of the National Conduit Fishing Machine.

which is to be wired. The crank is placed on the upper reel shaft and turned at any desired speed. This operation winds the propelling tape, *B*, from the lower reel, *L*, onto the upper one, *U*. Thereby the fishing tape, *T*, is projected from the machine and through the conduit. The force, due to which the fishing tape, *T*, is projected, is directly proportional to that applied by the hand to the crank, *C* (Fig. 529). It should be noted, however, that the force imparted to *T* at the machine is greater than that imposed on the crank handle because of the "leverage" due to

the 12-in. crank operating on the 5½-in. wheel. After the fishing tape, *T*, has been propelled through the conduit to the required conduit case, the insulated conductor, if the pull is to be a "light" one (or the pulling-in wire if the pull is to be "heavy") is attached to the tape. Then the crank, *C*, is detached from the upper reel and attached to the lower one. Now, on turning the crank both of the tapes are coiled back again on the lower reel and the insulated conductor or pulling-in wire is pulled back through the conduit.

**261. The Performance And The Cost Of Fishing With The National Conduit Fishing Machine** is apparently quite satisfactory. When the crank is turned at the average speed, the fishing tape is projected through the conduit at a velocity of 4 ft. per second. It is claimed that records of large installations involving a total of several million lineal feet of conduit show that the cost of fishing has been less than ¼ ct. per lin. ft. as against ¾ ct. to 1 ct. per lin. ft. for hand fishing.

NOTE.—THE ABILITY OF THE NATIONAL MACHINE TO FISH DIFFICULT RUNS is due, so the manufacturer claims, to the great force impressed against the fishing tape and to the greater velocity of the tape without any cessation of motion. It is understood that this machine will fish runs which have a large number of bends, which may be very difficult to fish by hand. It is claimed that a 100-ft. conduit run containing over 20 right-angle bends was successfully fished in a competitive test. In hand fishing, the operator can only shove the fish ribbon into the conduit to the limit of the sweep of his arm. The movement of the tape must then cease momentarily while he takes another hold. Each time his hold is changed there is a cessation of motion and a loss of momentum. When the tape is impelled by the machine, it is in motion constantly and hence the starting frictional resistance, which always occurs when anything is started from rest, is nullified.

**262. The Different Kinds Of Lines Or Wires Which May Be Used To "Draw In"** the conductors are as follows: (1) *Ribbon fish wire* of rectangular section. (2) *Galvanized steel wire* of round section. (3) *Cord* or *rope*. (4) *Chain*. These various lines all have uses for which they are best adapted. The fish wires are employed where possible since, by their use, the drawing in of a pulling-in wire is eliminated. Regardless of the character of the line which is used as a pulling-in line, the conductors which are to be drawn into the conduit should be attached thereto so that they can be installed with the expenditure of minimum time and effort.

**263. A Ribbon Fish Wire Can Be Used As A Pulling-In Line** after the run has been fished with it, where the run has but few bends, and the wire to be pulled in is not larger than No. 12 or No. 14 B. & S. gage. But it is inadvisable to draw in with a ribbon fish wire runs which pull hard or runs of heavy conductors. The reason is that the stress thus imposed on the ribbon fish wire takes the "life" out of it. Hence, a pulling-in line of some sort or other, which has been drawn through the conduit by using a fish wire, should always be used for drawing in heavy runs. When the labor cost is high, it may be more economical to pull in rather difficult runs with the fish ribbon and use a new one when necessary, as they are comparatively cheap, than to spend the additional time required for attaching a pulling-in line and drawing it through.

NOTE.—AFTER HEAVY WIRES HAVE BEEN PULLED INTO LONG RUNS WITH A RIBBON FISHING WIRE, it looses its original tendency to assume the form of a long straight ribbon and tends to roll and twist into curls This makes it very difficult to push through a conduit run and for rapid efficient work renders it almost useless.

**264. Galvanized Steel Wire Makes An Excellent Pulling-In Line,** No. 10 or 12 Birmingham Wire Gage is ordinarily used. If one strand of the galvanized steel wire is not sufficiently strong to sustain the stress imposed, several strands arranged in parallel can be used.

NOTE.—THE ROUND GALVANIZED STEEL WIRE IS OFTEN USED FOR FISHING and in this case the fish wire can be used for pulling in larger conductors. There is not the danger with this wire that there is with steel ribbon wire of straining it excessively. This is because of its greater cross-sectional area.

**265. Rope Or Cord Pulling-In Lines** are frequently used. Braided rope (Fig. 530), of the construction of that used for

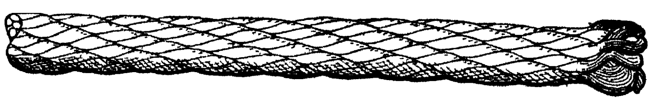


FIG. 530.—Braided rope or cord for pulling-in lines.

sash *cord,* is ordinarily employed for rope pulling-in lines although, for heavy-pulling runs, galvanized steel wire is better. *Twisted manila rope* is sometimes utilized, but it tends to untwist when subjected to tension. In untwisting,

the rope twists the conductors within the conduit, which causes them to "pack" and pull hard around the elbows. The insertion of a swivel (Figs. 531 and 548) between the end of a twisted-rope pulling-in line and the conductors to be drawn in will, in a measure, obviate these difficulties due to twisting. *Braided rope,* or as it is called by the trade "cord," is manufactured in a variety of diameters from 7⁄32 in. up

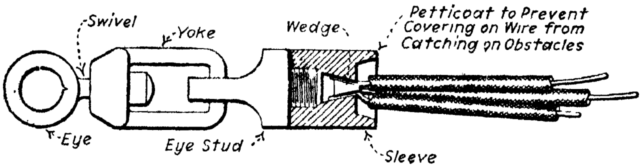



FIG. 531.—Swivel to prevent twisting.

to ½ in. and sometimes cords of larger diameters may be obtained. *Steel hoisting cable* such as that used on cranes is not desirable for pulling-in lines because of its high cost and tendency to cut when tied to a tackle-block hook.

NOTE.—GALVANIZED STEEL WIRE OR CHAIN IS BETTER THAN ROPE FOR HEAVY WORK. The rope is much more bulky for the same strength, is more expensive and wears out more quickly under severe usage. It is difficult to tie a rope to the hook of a set of tackle blocks with a knot which will not cut and thus sever the line. With rope, the fastening wires often pull out causing annoyance and much loss of time. Galvanized steel wire can be very quickly and positively secured to a tackle-block hook with a "come along" or wire grip (Fig. 558). Both the galvanized steel wire and the chain can be more securely fastened to the conductors to be drawn in than can the rope or cord.

**266. Steel Sash Chain** makes a good pulling-in line for some purposes. It is very strong, flexible, readily obtained, and

FIG. 532.—Sash chain pulling-in line.

economical. The type of chain shown in Fig. 532 has been found very satisfactory. Conductors to be drawn in can be readily attached to the sash-chain line at any point by tying them into the links. This feature is particularly convenient where there are a number of conduit cases along a run (Sec. 285) and conductors which are to terminate in each are to

be drawn in simultaneously. In pulling conductors into a vertical run, the sash chain may, of its own weight, be dropped down through the conduit, thus serving as both the fishing and pulling-in lines (Sec. 239).

**267. The Principal Requirements Of The Attachment Of Conductors To A Pulling-In Line** may be enumerated thus: (1) *The attachment should have ample tensile strength.* (2) *The attachment should offer minimum opposition to the drawing of the conductors into the conduit.* The requirement of tensile strength may be satisfied in an obvious way by so making the connection of the conductors to the pulling-in line that it will be sufficiently strong. This requirement is not difficult to satisfy provided the graphic and written instructions enumerated herein are followed. The requirement of minimum opposition to drawing in can also be met readily by a reasonable exercise of judgment and common sense. The attachment should always "taper gradually" (Fig. 533). That is, it should be conical in shape from the pulling-in line to the body of the conductors so that the joint will slide easily into the conduit and past irregularities therein without seizing. The conical form is made by serving tape over the attachment in such a way that the interstices are filled in. These requirements also apply to the attachment of the pulling-in line to the fishing wire.

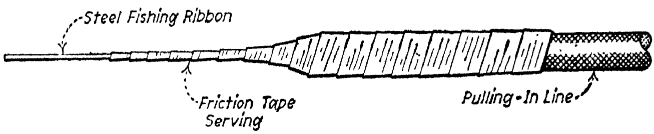


FIG. 533.—Taped over fishing ribbon attachment to rope pulling-in line.

NOTE.—THE IMPORTANCE OF A PROPERLY MADE ATTACHMENT cannot be over-estimated. If the attachment is weak it may fail during the drawing-in process. This will necessitate a re-fishing of the run. Furthermore, if the attachment is not properly made it may either "pull hard" (require excessive force to draw it through) or it may "stick" at some coupling or elbow in the run.

**268. Conductors May Be Attached To A Ribbon Fish Wire By The Method** illustrated in Figs. 534, 535, and 536. In this method the insulation is removed from both conductors

for a distance of about 3 in. The two conductors are attached together by tightly twisting (Fig. 534) around the insulation of the leading conductor, at a distance of about 5 or 6 in. from its end, the bared end of the other conductor. This joint prevents slippage under strain. The bared end of the leading conductor is also twisted carefully (Fig. 535) around the hook or through the loop of the fish tape or wire. Care must be taken not to kink or cut the conductor during the process. Friction tape (Fig. 536) is then wrapped around the two joints, beginning with the first joint between the leading conductor and the ribbon fish wire and gradually spiraling backwards until the second joint is covered. Under no circumstance should the tape be wound loosely or permitted to form a lump. Thus a long tapering attachment is provided which will draw readily into any conduit sufficiently large to receive the wire. The same general method may be used, if there are three instead of two wires to be drawn in.

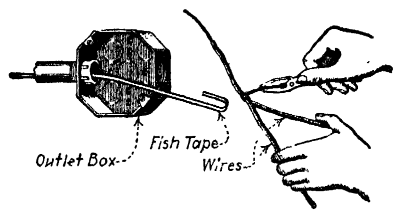



FIG. 534.—Joining the two conductors which are to be pulled into a conduit.

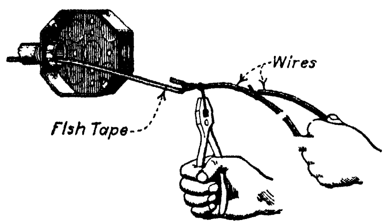



FIG. 535.—Taping the connections between the pulling-in wire and the conductors.

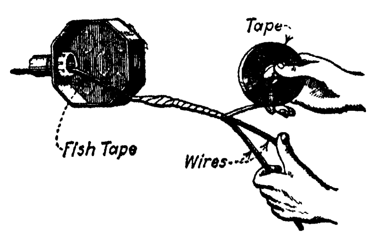



FIG. 536.—Attaching the conductors to the pulling-in line (in this case the fish tape is used for a pulling-in line).

NOTE.—IN "EASY" RUNS THE CONDUCTORS MAY BE ATTACHED TO THE RIBBON FISH WIRE, by twisting the bared ends of all the conductors around the hook or loop in the end of the fish wire. The whole joint should be served with friction tape. The method is probably the one most commonly used and in most cases it is very satisfactory.

NOTE.—AN ATTACHMENT TO A STEEL FISH WIRE WHICH MAY BE USED WHERE A HARD PULL is expected (it is understood that only small conductors—No. 12 or No. 14—for "easy" runs should be

pulled in with a fishing ribbon, hence this method is not, in general, recommended) can be arranged by forming a loop, *L* (Fig. 537), 3 or 4 in. from the end of the fish wire and then making up the conductor ends, *C*, in it as shown. The free end of the fish ribbon extends along the conductors and is lashed to them with turns of small-diameter binding wire. The entire attachment is served with friction tape so that it will offer minimum resistance.

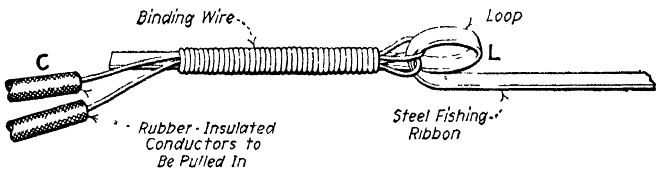



FIG. 537.—Conductors to be pulled in "made up" in a loop in a fishing ribbon.

**269. In Attaching Twin Conductors To A Ribbon Fish Wire,** the method suggested in Fig. 538 may be used where the run is short and relat vely straight. A slit (*H*, Fig. 538) is cut through the outer braid of the twin wire about 1 in. from its end. The end of the fishing ribbon is hooked through the slit, *H*, and bent down as at *R* so that it will not catch

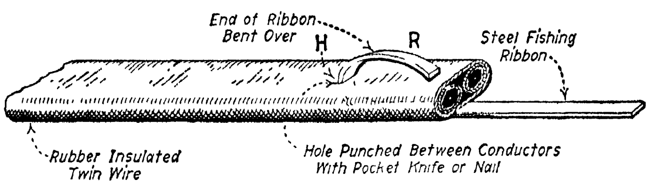



FIG. 538.—Showing how steel fishing ribbon may be hooked through twin wire for drawing in.

inside of the conduit. The braid, due to the fact that it is composed of many strands crossing one another, does not tear out readily. This method consumes much less time than does one where the "skinned" ends of the conductors must be made up in a loop on the end of the fishing wire, and should be used where possible.

NOTE.—IN DISPOSING OF THE OUTER BRAID COVERING ON TWIN WIRE SO THAT THE WIRE WILL PULL IN READILY the procedure diagrammed in Figs. 539 and 540 may be followed. It sometimes occurs, unless proper precautions are taken, that the outer braid of the conductors being pulled in will slide back and form a lump around the

conductors (Fig. 541). Such difficulties may be avoided if the outer braid is first ripped longitudinally with a knife (Fig. 539) and then folded back (Fig. 540). Where this is done it may be unnecessary to serve a tape covering over the attachment.

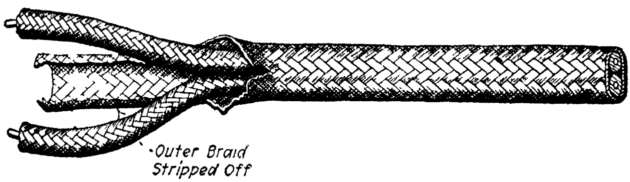



FIG. 539.—Outer braid stripped off.

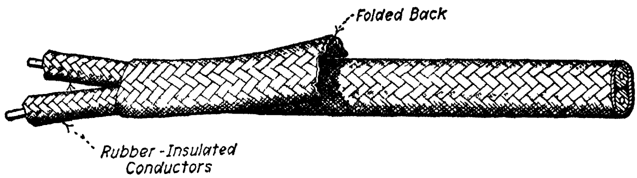



FIG. 540.—Outer braid folded back.

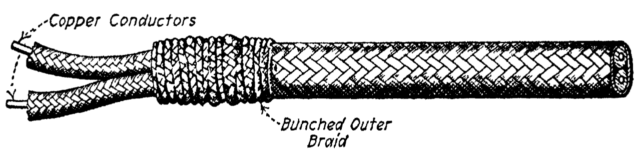



FIG. 541.—Showing how the outer braid may "bunch up" on the outside.

**270. A Method Of Attaching A Rope Pulling-In Line To A Steel Fishing Wire** is delineated in Fig. 542. If the conduit has been fished with a steel-ribbon fishing wire and conductors

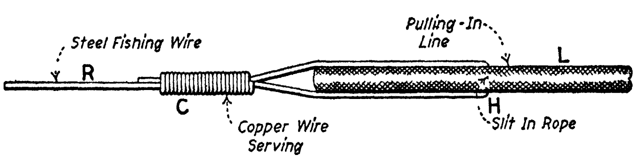



FIG. 542.—Showing how fishing ribbon may be attached to rope pulling-in line.

larger than No. 12 are to be drawn in, it is best to draw in a pulling-in line with the fishing wire, rather than to attempt to pull in the conductors with the fishing wire, for reasons hereinbefore outlined. The fishing ribbon, *R* (Fig. 542), is made

fast to the pulling-in line, *L*, by inserting it through a slit which has been cut in the rope at *H*. A serving, *C*, of small-diameter copper wire is made around the free ends of the fishing wire. Then the entire attachment is covered with friction tape (Fig. 533) so as to form a conical wedge shape.

NOTE.—FREQUENTLY ROPE PULLING-IN LINES HAVE LOOPS BRAIDED IN EACH OF THEIR ENDS. Into one of these loops the fish wire used for drawing in the pulling-in line, or the conductors which are to be pulled into the conduit with the pulling-in line, can be attached. These loops are preferable to the insertion method (Fig. 542) described above because they will not pull out so easily.

**271. In Attaching Two Medium-Sized Conductors To A Rope Pulling-In Line Which Has Not A Loop In Its End** the method of Fig. 543 can be used. The bared end of one of the conductors, $C_1$, is passed through a slit, *S*, cut in the rope and

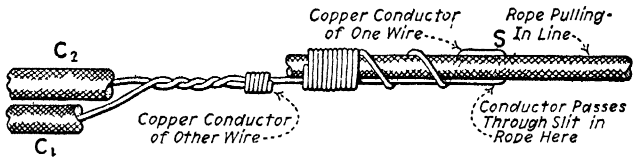



FIG. 543.—Attachment of two copper conductors to rope pulling-in line.

is made up about the end of the rope as suggested. Then the bared end of the other conductor, $C_2$, is made up around $C_1$ as shown. To complete the attachment, serve it with friction tape. All of the components should be so disposed that the

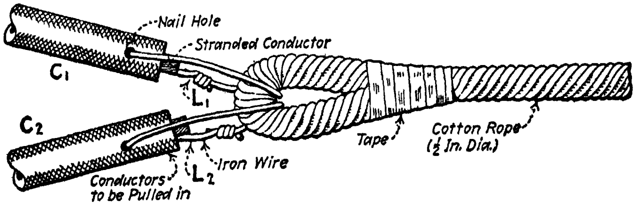



FIG. 544.—Showing attachment prior to taping.

attachment will taper from the rope toward the conductors. This may be effected by filling in the low places in with the friction tape.

NOTE.—IN ATTACHING MEDIUM-SIZED STRANDED CONDUCTORS TO THE LOOP IN THE END OF A ROPE PULLING-IN LINE, short links, $L_1$

and $L_2$ (Fig. 544) can be used for fastening the conductors, $C_1$ and $C_2$. These iron wire links are threaded through holes, punched through $C_1$ and $C_2$ with a nail. Fig. 545 shows the attachment partially taped. The completed attachment should be entirely taped over, as suggested in Fig. 550.

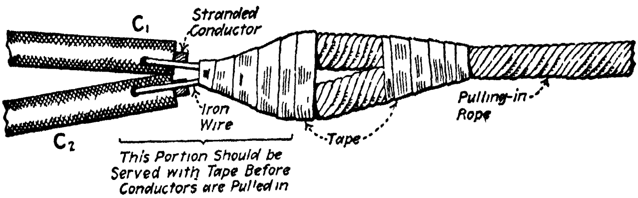



FIG. 545.—Attachment partially taped.

NOTE.—A METHOD OF MAKING AN EYE IN THE END OF A PULLING-IN ROPE is shown in Fig. 546. Four holes are made in the rope with a nail and a No. 10 iron wire is wound around the rope and through the holes as shown. The stranded conductors or cable wires are then inserted through the hook, twisted around as shown, and soldered.


FIG. 546.—Loop made up in pulling-in-line end for attaching pulling-in line to a cable or stranded conductor.

**272. Cable Grips Are Economical For Attaching Large Conductors To Pulling-In Lines** (Fig. 547).—The cable grip, due to the spring formation in the interlacing of the strands, applies an even pressure to all sides of the cable simultaneously, which


FIG. 547.—Single-eye cable grip. This cable grip is also made in many sizes and in double-eye split grip types. (*Universal Cable Grip Co., Syracuse, N Y.*)

is intensified when the strain is put on the pulley eye. In using the grip, its ends are pushed together, thus enlargening its diameter. The grip is then slipped onto the cable into such a position that when it is again stretched out, the eye will project about 6 in. from the end of the cable. Cable grips

will not injure the conductor and if sufficient care is taken to attach them properly, they will not pull out. A steady pull should be exerted on the line because the holding power of the cable grip increases with the strain put upon the pulling-in line and the eye. It is much quicker to attach a cable grip to the large conductor than to make up a splice. The resulting attachment is also more secure and requires less space than does the large splice joint. Several small conductors instead

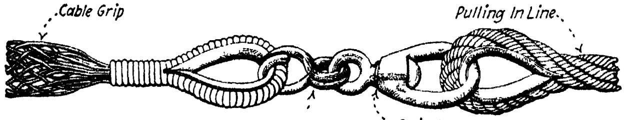



Fig. 548.—Swivel sister hooks used for attaching pulling-in line to a cable grip. (*Universal Cable Grip Co., Syracuse, N. Y.*)

of one large one may also be attached with the cable grip. Some wiremen remove the insulation before attaching the grip to a cable, but this does not appear to be always necessary. In any case, the rear end of the grip should be taped to the conductor at a distance of at least 4 in.

Note.—A Swivel Sister Hook (Fig. 548) is very convenient for attaching a cable grip to a pulling-in line which is provided with an eye on its end. The *sister hook* provides for easy attachment and the swivel prevents twisting of the conductors.

**273. An Improvised Attachment Similar In Principle To The Cable Grip** (Figs. 549 and 550) may be employed. The complete attachment with its tape serving as it is ready to be drawn into the conduit is shown in Fig. 550. In making up this attachment a piece of No. 10 iron wire (Fig. 549) about 4 ft. long is looped around the end of the cable once as shown at *I*. Then the two free ends of this iron wire are wrapped around the cable, in opposite directions, so that about 3 or 4 in. of free wire is available at the ends for attaching to the loop in the pulling-in rope. The wires completely made up are shown at *II*. Finally, a tape wrapping is served over the attachment to prevent fouling. It is false economy to be stingy with the tape. It protects the end of the cable, strengthens the connection, and keeps the free ends (which

might otherwise catch on obstructions on the interior of the duct) on the inside where they belong. This attachment while effective is not as economical as the commercial cable grip, (Fig. 547) because of the time required to make it.

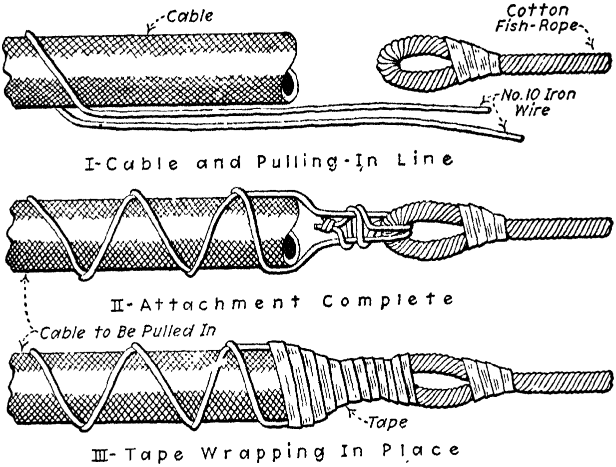



FIG. 549.—Attachment of a heavy conductor to a pulling-in line.

NOTE.—AS TENSILE STRESS IS IMPRESSED UPON THE CONNECTIONS of Figs. 549 and 550, the galvanized iron wire "bites" into the insulation on the cable. The greater the pulling force, the "harder" the iron wires, which have been woven around the cable, will bite into it. For these reasons an attachment of this type is very effective.

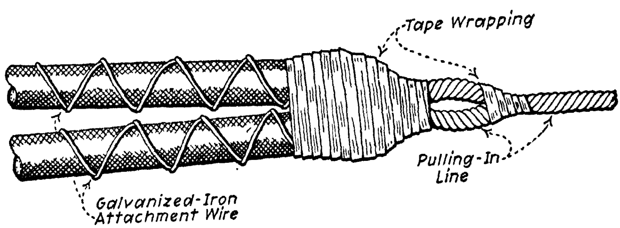



FIG. 550.—Two heavy conductors attached to pulling-in line.

**274. In Tying A Rope Pulling-In Line Direct To Heavy Conductors** a knot of any one of several types may be used. In Fig. 551 is delineated the "rolling hitch" which will grip firmly into the insulation on a large conductor. All of the

turns should lie close together and be pulled up tight before the pulling stress is imposed. Half hitches made around the conductor at the pulling end, *P*, of the knot will increase its

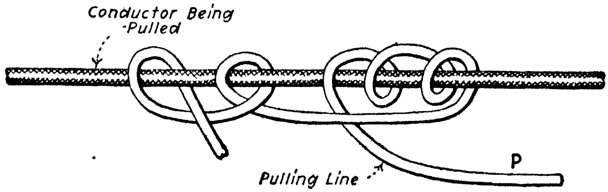



FIG. 551.—Rolling-hitch for attaching rope pulling-in line to the conductor.

gripping power. A "non-slip-hitch" (Fig. 552-*II*) can often be successfully used.

NOTE.—TO TIE THE NON-SLIP HITCH, pass the bight of the sling around the conductor and pass the sling through the bight as shown at

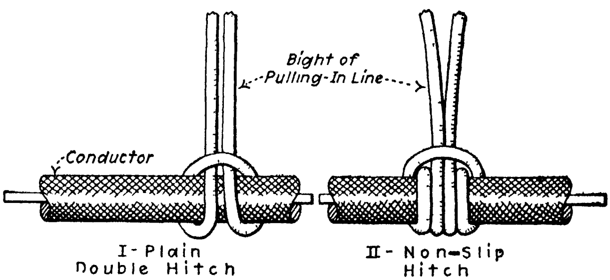



FIG. 552.—The non-slip hitch for attaching rope pulling-in line to the conductor.

*I*, making a plain double hitch. Now pass the bight around the conductor again and slip the end of the sling through the bight. Pull the strands tight and the resulting knot will appear as at *II*. This hitch is very easily tied and is extremely effective.

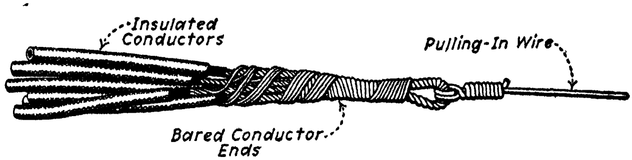



FIG. 553.—Group of single conductors attached to a pulling-in wire.

**275. In Attaching A Group Of Small Conductors To A Pulling-In Line** the ends of all of them are first bared. Then a number of these bared ends are twisted into a cable (Fig.

553) which is made up into a loop in the end of the pulling-in line. Now the bared ends of the remaining conductors are so made up about the little cable thus formed that the "conical wedge" form, referred to previously, results. Finally, the attachment is served with tape (Fig. 554) so that it will offer minimum resistance inside of the conduit.

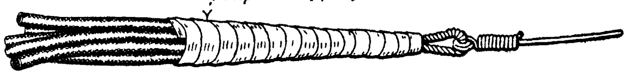



FIG. 554.—Attachment taped over and ready for pulling in.

**276. When More Than Two Conductors Are To Be Pulled Into A Conduit Run,** each pair of conductors should be marked so that it can be readily distinguished from the other pairs. By marking the pairs of conductors, much time is saved in splicing and identification testing out the circuits (Sec. 292). Various methods of marking may be employed. One method is to *cut the insulation* on the ends of each pair of conductors, differently. For example, cut off the insulation on one pair straight, taper the insulation on another pair, and so on. Another method is to tie *tags* or *various colored strings* on the ends of each pair of conductors. It is not so important which method is used, because one is about as good as another (although the tieing of strings or tags on the conductor ends is usually the quickest method). The important consideration is that by properly marking all pairs of conductors, when more than two conductors are located in one conduit, practically all identification testing out is eliminated. It is generally more economical to mark the conductors than to test them out for identification when splicing and taping them. The wireman who feeds in the conductors can mark the last ends of the preceding run and their forward ends of the next run while the other wireman is fishing the run.

NOTE.—IF REELS ARE USED THEY SHOULD BE MARKED IN SOME MANNER to correspond to the markings on the conductors. When this is done the forward end of the conductors (where they are attached to the pulling-in line) can be marked and the conductors pulled in direct from the reels. After the conductors have been pulled in they can be cut off and their other ends marked to correspond to their forward

ends, by noting from what reels they were taken. This method is preferable, where many runs are pulled in from one place (distribution point) to that method in which the conductors are all pulled out on the floor, cut to length, marked on both ends and then drawn into the conduit. However, where many reels would be required or where only one short run must be pulled in from a given location, the latter method of first laying out the conductors may prove the more economical.

NOTE.—WHEN TAGS ARE USED IT MIGHT NOT BE POSSIBLE TO ATTACH THEM TO THE FORWARD ENDS OF THE CONDUCTORS BEFORE THEY ARE DRAWN INTO THE CONDUIT because the tags usually take up considerable space. They may also catch and come off during the pulling-in process. In such cases the conductors may be arranged on the pulling-in line in an *identifying sequence* by fastening them in a certain order on the line (Fig. 555). After the conductors are drawn

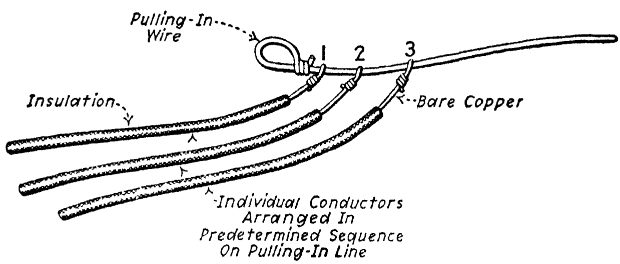



FIG. 555.—Arrangement of conductors which are to be pulled in, in a predetermined sequence on the pulling-in line for identification.

in, the ends can be tagged as they are taken off the pulling-in line. The other (back) ends of the conductors can be marked or identified by either of the two methods already described. When the conductors are drawn into the conduit directly from the reels, they can be marked by noting the reel from which they were drawn. In the other method where the conductors are cut to the proper length and made up on the floor, the back end of each conductor is marked or tagged to correspond to the position of the conductor on the pulling-in line; that is, the one end of the first conductor is made up around the pulling-in line in the No. 1 position and the other (back) end is tagged "No. 1" or is wrapped in No. 1 position around a short dead length of wire called a "dummy' wire. Each succeeding wire is handled in a similar manner.

**277. Prior To Pulling In, The Interior Of The Conduit Should Be Cleaned.**—Sometimes oil, water, plaster, cement, and dirt accumulate inside of the conduit while the building is being constructed. Obviously, these materials should be removed before the conductors are drawn in. Some of the methods of removal have been described in Secs.

230 to 236 relative to fishing. A rapid, effective expedient is to pull a piece of waste through the duct before drawing in.

NOTE.—A VERY EFFECTIVE DEVICE FOR REMOVING WATER FROM A CONDUIT is shown in Fig. 556. The device is pulled through the conduit from the conduit case at the highest point of the run and forces all water before it and out of the other conduit cases. It should, preferably, be run through several times. The leather washer should be removed and a number of cloth discs substituted therefor before the final pull, so as to wipe the walls of the conduit clear and dry. To save the trouble of refishing after each time this cleaner is pulled through, a pulling-in line should be fastened to the rear of the device between the washer and the machine screw.

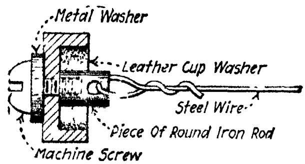


FIG. 556.—Simple device for removing water from a conduit run.

**278. Lubrication Of The Conductors** is desirable when pulling them into the conduit. Particularly is it necessary in hot weather and for long runs. When the insulating compound on the conductors is warm, it seeps through the braid and adheres to the interior surface of the conduit making it difficult to pull in the conductors. The best lubricant to use is powdered *soapstone*, sometimes called *powdered talc* or *French chalk*. It may be either blown into the conduit with a piece of hose or applied to the conductors as they are pulled in. Some wires have a coating of powdered mica applied to their outer braids which acts as a lubricant and tends to insure "easy drawing in."

NOTE.—IN BLOWING POWDERED SOAPSTONE INTO THE CONDUIT, a length of rubber hose about 2 ft. long is partially filled with the material. One end of the hose is held against the bushing at the conduit opening so as to fill the orifice. Then the wireman blows on the other end of the hose with his mouth, forcing the powder inside of the conduit.

**279. Greases, Oils, Nor Soap Should Never Be Used As Lubricants** when pulling in conductors. They act chemically on the rubber insulation causing it to soften rapidly and lose its insulating properties. The practice of pulling a greased cloth through a conduit run prior to the insertion of conductors is emphatically condemned. Numerous cases are on record where oil has been poured into conduits for lubrication.

Where this has been done insulation failures, grounds, and burn-outs have almost invariably resulted.

Note.—Paraffin Has Been Used For A Lubricant where conductors are being pulled in but apparently its use is not frequent. In using paraffin, a block of it is rubbed against the conductors as they are drawn into the tube. Paraffin is a splendid insulator and is, therefore, unobjectionable from this standpoint. However, an excess of paraffin on the braids of the conductors within the conduit may cause the braids to adhere to the inner walls of the conduit and thereby prevent their withdrawal.

**280. The Force Required To Pull In The Conductors Should Never Be Excessive.**—This statement should be interpreted in a relative sense as the force required to pull in the conductors will vary with their size. However, it should always be possible to pull No. 14 conductors into the conduit with the hands. Heavy cables may require tackle or cranes for their insertion. In ordinary cases the conditions should be made such that the force required to pull in the conductors will be the minimum consistent with good economy. The *conduit* should be large enough so that there is plenty of room for the conductors. The bends between pull and outlet boxes should be as few as possible. Undersized conduits and an excessive number of bends will render pulling-in extremely difficult and may, after the conductors have become "set" within the conduit, render withdrawal impossible. This would defeat one of the chief features and advantages of the conduit method of wiring. A steady pull of minimum intensity will be more effective than an intermittent jerk of greater intensity, and will not injure the conductors as readily. It is a good rule never to jerk the pulling-in line but apply a constant pull instead.

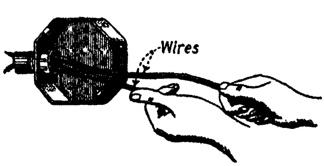


Fig. 557.—"Feeding" the wires into a conduit during the pulling-in.

Note.—Conductors Are Usually Drawn In By Pushing And Pulling Simultaneously. While one or two men are pulling the conductors out at the far end of the run, another man can accelerate progress by pushing or feeding (Fig. 557) the wires into the other end. This man (the *"feeder"*) can prevent the formation of kinks and can "ease" the wire over the abrupt edge at the conduit case. The guiding of the

conductors into the conduit orifice is called "feeding" (Fig. 557) and the man who does it is called the *feeder*.

**281. It Is Difficult To Obtain A Secure Grip With The Hands On Ribbon Fishing Wire When Pulling In.** Hence, it is almost impossible to pull by this method against any considerable strain. Wiremen sometimes bend the bight of the wire around a stick or otherwise distort it to enable them

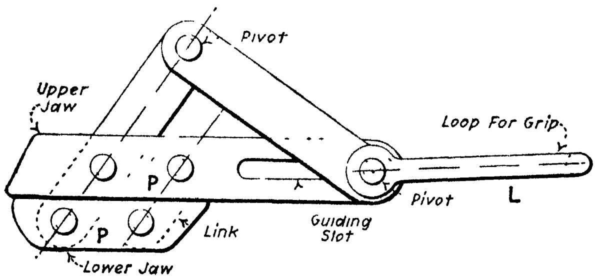



FIG. 558.—Parallel-jaw wire grip.

to gain a hold. Such a procedure is bad practice. The kinks so formed in the ribbon fish wire can never be removed entirely although they apparently may be removed. A ribbon thus punished will always give trouble when used for future fishing. A fish-wire puller (Figs. 558 and 559), which will not kink the wire should be used for gripping it. These devices will save considerable time in pulling in conductors with fish wires.

NOTE.—A PARALLEL JAW GRIP OR "COME-ALONG" CAN BE USED IN GRIPPING FISH WIRES (Fig. 558). Grips of this type are used extensively in aerial line construction. If the surfaces of the edges of the two parallel plates, *P*, between which the wire is clamped, are smooth they will not mar the ribbon. The fact that grips of this type are used successfully for pulling up hard-drawn copper aerial line wire is sufficient recommendation. A spring (not shown in the illustration) with which the grip is equipped tends to clamp it lightly on the wire, preventing it from falling off. When a tensile stress is applied at the loop, *L* (Fig. 558), the clamping effect is greatly intensified. Three sizes of this clamp are manufactured. Each respectively is capable of accommodating from an indefinitely thin wire to a No. 6, No. 0, or No. 000. In

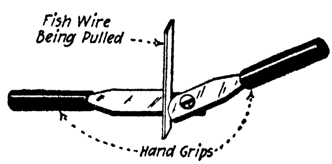



FIG. 559.—A non-slip fish-wire puller. (*T. J. Cope, Philadelphia, Pa.*)

using the grip, it is clamped on the wire to be pulled and a short rope is tied into the loop, *L*. The rope provides a good hold for the wireman's hands.

**282. Tackle Blocks Provide The Usual Method Of Obtaining The Desired Force For Pulling In A Heavy Run.**—One block of the set is provided with a loop and the other with a hook. The block with the loop is made fast to some substantial object and the hook of the other block is engaged with the pulling-in line. It may be knotted thereto if the line is of

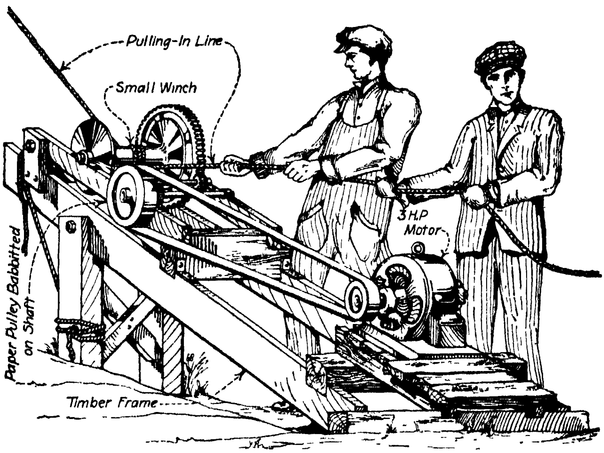



Fig. 560.—Pulling-in wire with a motor-driven winch.

rope or clamped with a parallel jaw grip if the line is of wire. Able-bodied wiremen helpers pulling at the far end of the tackle-block rope supply the force. Obviously, it is merely a matter of enough men and sufficiently heavy tackle to pull in the most difficult run. But it is slow work. The ordinary tackle blocks have three or four pulleys each. This means that the men must carry the far end of the tackle block rope from the blocks, six or eight times the distance that the conductors are drawn into the conduit. Each time the blocks are pulled to the limit, the pulling-in line must be disengaged from the block hook, and the blocks pulled as far apart as the line will permit. Then the blocks must be again made fast to the pulling-in line and the process repeated.

NOTE.—A MOTOR-DRIVEN WINCH MAY BE USED FOR PULLING IN CONDUCTORS (Fig. 560). An old winch (Fig. 560) was modified by removing the crank and babbiting a pulley on to the shaft. Then the wihch and the 3 hp. motor were bolted to a couple of timbers. In pulling, the line is given a few turns around the drum of the winch and the motor started. In the meantime the wireman keeps the line taut by exerting a force on its free end as shown. The power winch is more desirable than the tackle blocks because it supplies a more uniform and constant pulling force.

NOTE.—AN IMPROVISED DEVICE FOR PULLING IN CABLE is shown in Fig. 561. A long 1½-in. pipe, *S*, is passed through a 2-in. tee, *T*.

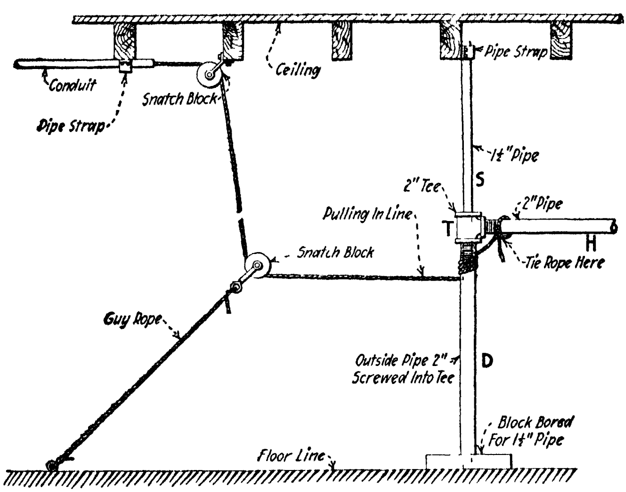



FIG. 561.—Improvised winch for pulling cable through conduit.

Into *T* is screwed a piece of 2-in. pipe, *D*, to act as a drum for the rope and another piece of 2-in. pipe, *H*, to form a lever handle. The upper end of *S* is fastened to a beam on the ceiling by means of a pipe strap. The lower end of *S* is fastened into blocks which are attached to the floor. The pulling-in rope is passed through snatch pulleys and tied to *H*. By turning *H* the pulling-in rope is wound around *D*. *H* must always be turned to the right to prevent its being unscrewed from *T*. It will be found that a large leverage can be obtained with this device.

**283. Conductors May Be Pulled In With A Crane** (Figs. 562, 563, 564, 565, 566, and 567).—The pulling-in line, *L*, is usually of galvanized steel. To insure that the pulling-in line will pass directly out of the branch conduit without excessive binding it is run over a snatch block arrangement

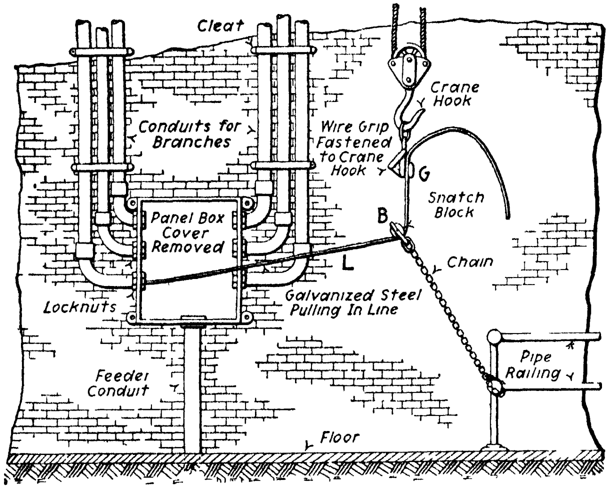



FIG 562—Pulling in wire with a crane hook.

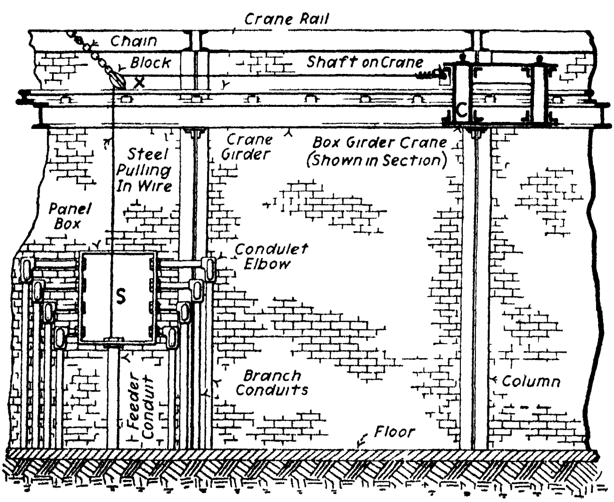



FIG 563.—Drawing in conductors with the pulling-in line attached to the frame of a bridge crane.

(*B*, Fig. 562) or over a sheave mounted in the box (Fig. 568). In the method shown in Fig. 562 the crane hook is used to pull in the conductors. An arrangement for pulling in a vertical feeder with a bridge crane, by attaching to the bridge is illustrated in Fig. 563. Where feasible, it is preferable to

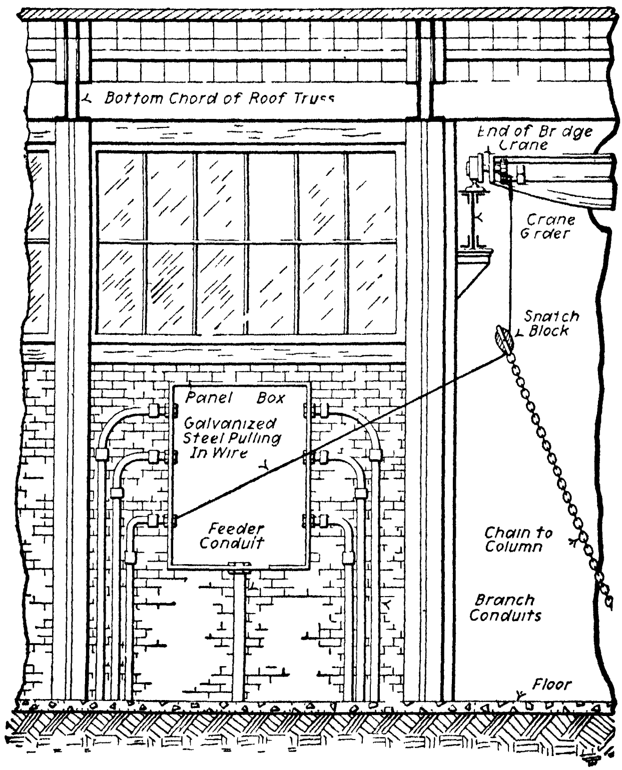



**FIG. 564.—A pull "around a corner."** (The plan view of this arrangement is shown in the next illustration.)

attach the line to the crane bridge rather than to the hook because the crane bridge speed is greater than that of the hook. Another reason is that it is usually possible to pull in a greater length of wire at one setting if the pulling-in line is attached to the bridge instead of to the hook. The pulling-in line may also be attached to a monorail crane (Fig. 566).

Note.—Pulling In With A Crane May Be Done "Around A Corner" (Figs. 564 and 565). In such an arrangement a snatch block is necessary and very often several snatch blocks must be used. But unless too many changes in pulling-in-line direction are necessary, it will probably pay to use the cranes. In a building where there are cranes it is seldom that any conduit case will be so situated that a pulling-in line cannot be pulled from it, in some way or other, by one of the cranes.

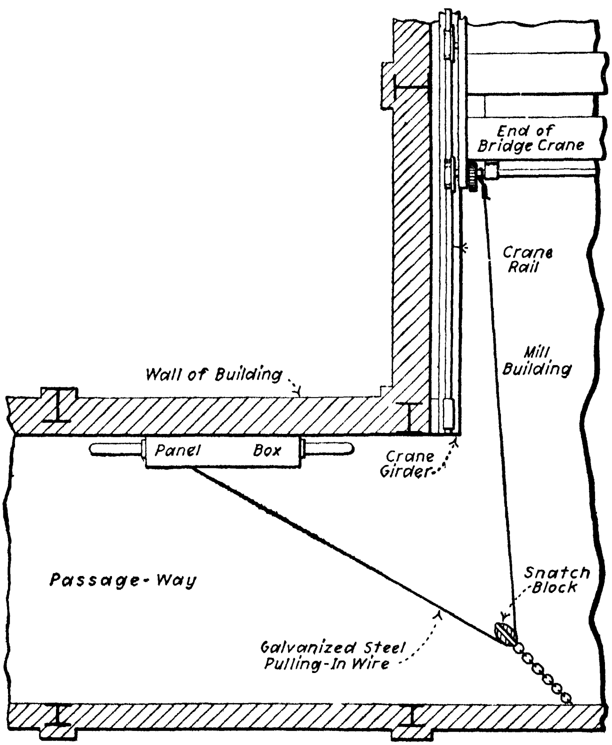



Fig. 565.—Plan view of the "pulling-around-a-corner" arrangement of the preceding illustration.

Note.—Locomotives Or Trucks May Supply The Pulling-In Force. Occasionally conditions are such that the yard locomotives in industrial plants may be thus pressed into service. In certain installations many hundreds of feet of conductors have been drawn in by this method. Many of the electric public-service companies use trucks and *tractors* for pulling in their large cables. When either trucks, loco-

motives or tractors are used care must be taken not to exert too great a force on the conductors.

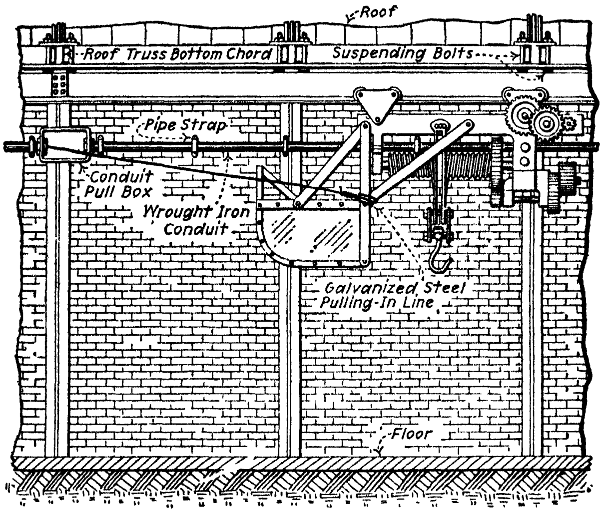



FIG. 566.—Pulling in conductors with a monorail crane. (Should the wheel slip on heavy pulls, two or three cranes may be coupled in tandem. If this fails, the pulling-in line should be re-routed so that pulling can be done by the crane hook.)

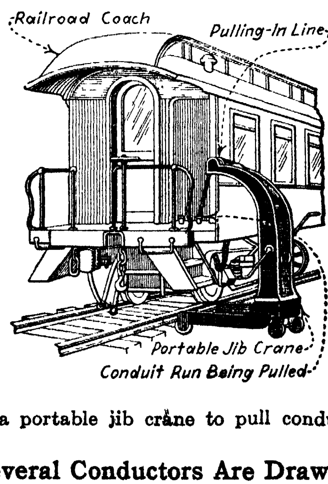



FIG. 567.—Using a portable jib crane to pull conductors into conduit.

**284. When Several Conductors Are Drawn Into The Same Conduit They Tend To Twist About One Another** into a cable arrangement. This twisting of the conductors, since the

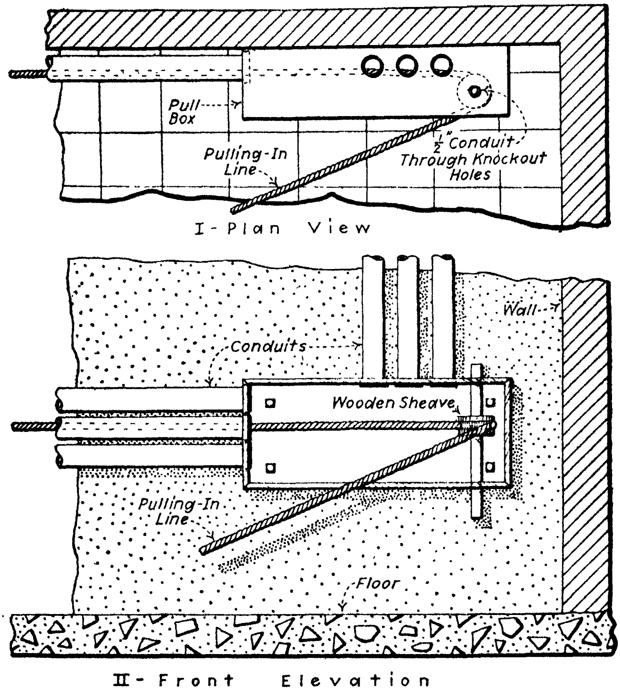



FIG. 568.—Sheave for pulling-in line in confined location. This method is particularly applicable where the pull box or outlet is located in a corner and a direct longitudinal pull is impossible. (The electrician should plan in advance and have the knock-out holes to support the axle punched in the pull box when it is being made.)

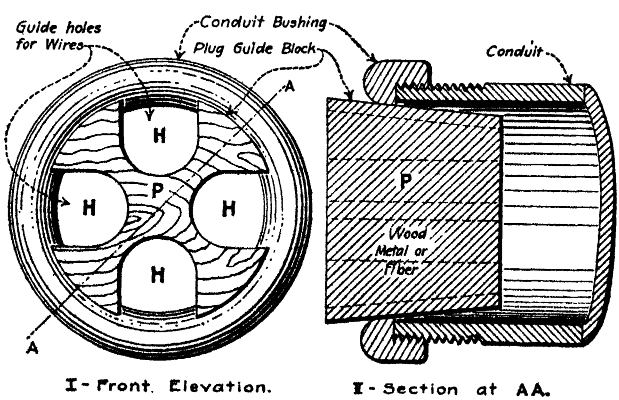



FIG. 569.—Plug-type guide block.

overall diameter of a group of twisted conductors is greater than the diameter of the same group when the conductors lie parallel, may cause them to bind in the conduit and thereby prevent their withdrawal. To eliminate this binding action, it is advisable to guide the conductors into the conduit so that they will lie parallel therein and will not kink or twist around. The small conductors are usually guided through the fingers of the man who is feeding. For guiding large conductors or a large number of small conductors, *guide blocks* of the types detailed in Figs. 569 and 570 may be used. The manner of employing the guide is illustrated in Fig. 571.

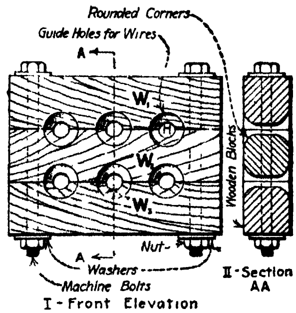



Fig. 570 —Split-type guide block to prevent twisting.

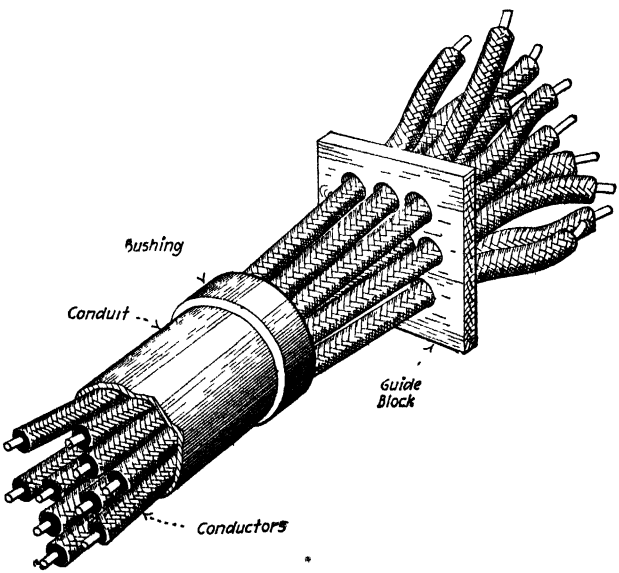



Fig. 571.—Arrangement of conductors when they are guided into the conduit by means of a guide block.

Note.—The Holes In The Guide Block Can Be Marked Or Numbered so that the pairs of conductors may be identified. When

this is done, the reels do not have to be identified (Sec. 276) as the ends of the conductors, after they are drawn in, can be marked directly from the guide block holes.

**285. When Drawing In "Tap-Off Conductors" Simultaneously With Through Conductors** (Fig. 572 and 573) they

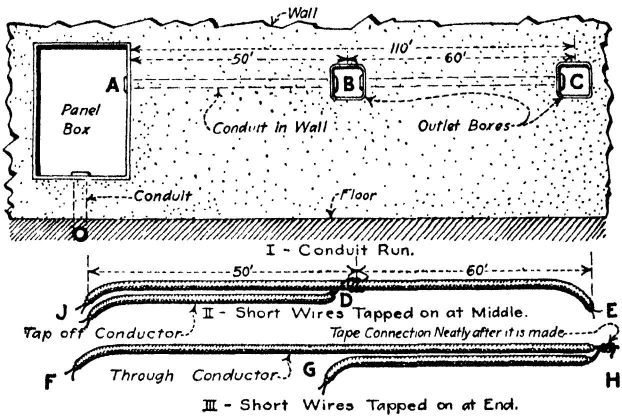



FIG. 572.—Showing methods of tapping on a short wire for drawing in.

should all be pulled in together. By *tap-off conductors* are meant short conductors which terminate at any conduit case nearer to the pulling-in location than the most distant conduit case on the conduit run. By *through conductors* are meant

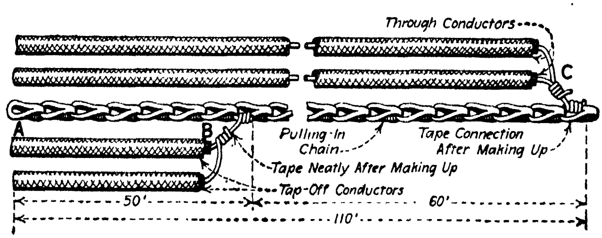



FIG. 573.—Showing how "tap-off" and "through" conductors may be attached to pulling-in chain.

those which extend through the entire conduit run from the pulling-in location to the farthest conduit case. It is seldom possible to first pull into a conduit, a portion of the conductors which are to be installed therein and then re-fish the conduit and draw in the remainder. If four conductors are to be

drawn in, all four should be pulled through together until the tap-off outlet where the shorter wires are to terminate is reached (Fig. 572). Then the short ones are held stationary while the longer ones are drawn on through to their destinations.

EXPLANATION.—THE PREFERABLE METHOD OF DRAWING IN THE TWO WIRES (Fig. 572), when one is to extend from *A* to *B*, and the other from *A* to *C*, is to tie both of them together at *H* for pulling in (Fig. 572-*III*). When the pair has been drawn from *A* as far as *B*, *GH* would be disconnected and held stationary but *FH* would be pulled on through to *C*. Difficulty is liable to be experienced if an endeavor is made to make up the short tap-off wire around the insulation of the other wire as at *D*. The attachment is liable to fail—slip and jam in the conduit. Furthermore, the short-wire conductors, *J D*, twisted around at *D* will cut into the insulation and may weaken the conductor *JE* so that it might break.

NOTE.—IN PULLING IN TAP-OFF AND THROUGH CONDUCTORS WITH A CHAIN PULLING-IN LINE they can be attached to the line as proposed in Fig. 573. The through conductors, *AC* (assumed to be 110-ft. long), are attached to the chain pulling-in line at *C*. The tap-off conductors (assumed to be 50 ft. long) are fastened to the pulling-in line at *B*. This method is feasible with a chain pulling-in line because of the ease with which the conductors, which are to be drawn in, may be attached to the chain links at any location.

**286. Conductor Ends Should Be Left Extending From The Outlets** to permit of splicing, making up and tapping on through wires. At switch and fixture boxes a free end 6 in. long is ordinarily sufficient where the conductors are small. But, where they are large, a greater length may be necessary. At the panel boxes, the proper length for the extending free end will be determined by conditions. The conductor must be long enough to reach the switch or cut-out terminals to which it is to be connected. After the conductors have been pulled in, the next steps toward the completion of the installation are connecting and soldering which will be treated in the subsequent division.

**287. The Conductors In Vertical Conduit Risers Should Be Supported Within The Conduit System** (Fig. 574) to prevent excessive strains. These strains may be due to the weight of the conductors, being imposed on the lugs and binding posts of the switches or cut-outs to which the conductors

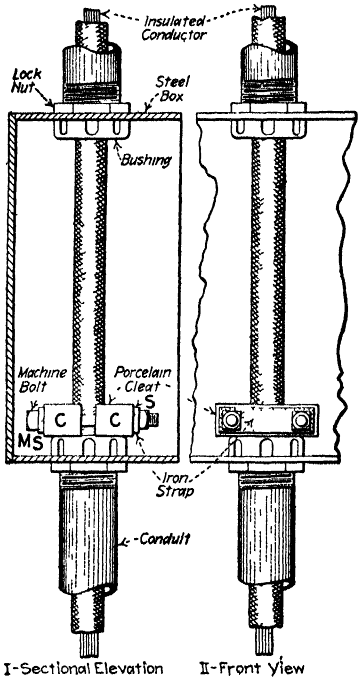



FIG. 574.—Conductor in a vertical conduit run supported with a clamp.

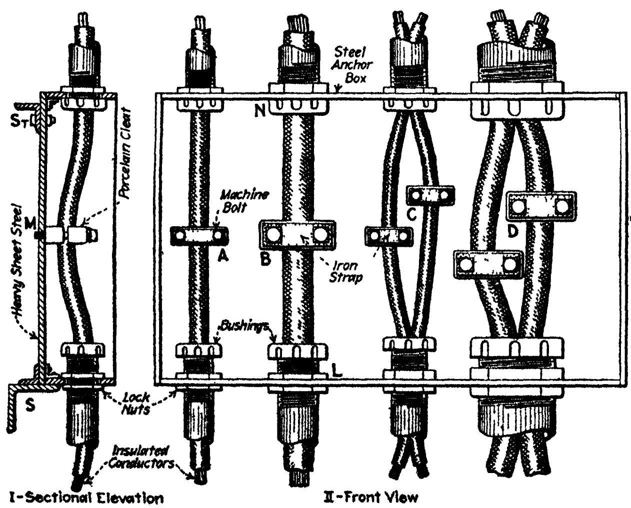



FIG. 575.—Supports for conductors in vertical conduit runs.

connect. Any one of several methods of supporting the vertical conductors may be used. One method (Fig. 574), which is satisfactory for the smaller conductors, is to bolt a porcelain cleat tightly around the conductor. Any other fireproof insulating material may be used. The cleat clamp rests on the conduit bushing in the bottom of the box and thus prevents the conductors from moving vertically downward. A bushing type of cable support (Fig. 578), which is similar to that just described, is very satisfactory for sustaining cables in boxes which contain many runs. These supports are not any larger in diameter than the standard conduit bushing, and thus require little space. They can be obtained for one, two, three, or more conductors. In a box with a heavy sheet-steel back, the cleats may be fastened to the back of the box (Fig. 575). A piece of strap iron is placed over the cleat to distribute the strain and prevent cracking the porcelain. Another clamp which is fastened to the back of the box or to an angle iron is shown in Fig. 576.

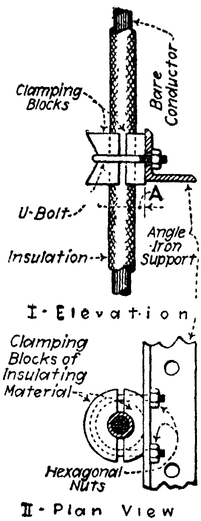


FIG. 576.—Supporting clamp for vertical conductors.

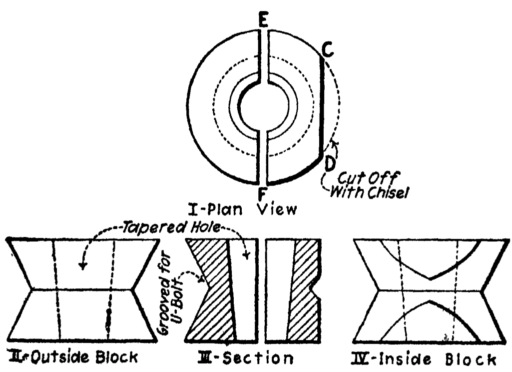


FIG. 577.—Details of insulating clamping blocks.

EXPLANATION.—This support consists of two insulating clamping blocks (Fig. 577) which are fastened around the conductor and held to

an angle-iron support by means of a U-bolt (Fig. 576). Frequently, it is feasible to pass the U-bolt through the steel plate forming the back of the box instead of through an angle iron.

NOTE.—IN SUPPORTING A LARGE CABLE, the insulation of the conductor is removed and the metal clamp soldered to the conductor. The metal clamp is fastened to an insulating panel in the back of the box.

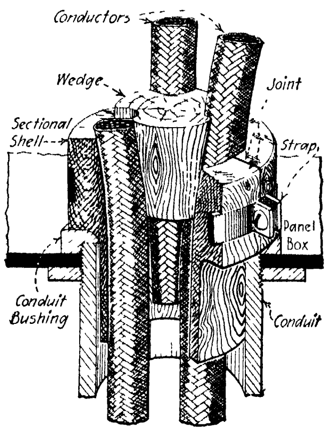



FIG. 578.—A three-conductor bushing type cable support. The support is made for any number of conductors that can be accommodated in the conduit. The shell and wedge are of an insulating material. The shell is made in a number of sections equal to the number of cables to be supported, and is held together by a metal strap. The whole support slips into the conduit bushing as shown. (*O. Z. Cable Support Co., Brooklyn, N. Y.*)

NOTE.—THE NATIONAL ELECTRICAL CODE SPECIFIES THAT ALL "CONDUCTORS IN VERTICAL CONDUIT RISERS* MUST BE SUPPORTED, within the conduit system, in accordance with the following table":

| Wire size | Distance between supports |
|---|---|
| 14 to 0 | Every 100 ft. |
| 00 to 0000 | Every 80 ft. |
| 0000 to 350,000 C.M | Every 60 ft. |
| 350,000 C.M. to 500,000 | Every 50 ft. |
| 500,000 C.M. to 750,000 | Every 40 ft. |
| 750,000 C.M. and above | Every 35 ft. |

**288. The Pulling-In Of Wires Affords An Opportunity To Check Up Conduit Boxes.**—On any job there are always a number of conduit boxes which will require adjustment later, due to their being incorrectly installed or to variations in plaster, etc. The wiremen may be instructed to note, when he is pulling in conductors, any boxes which will require attention. In this manner, the process of pulling-in conductors may afford an opportunity to check the entire job for incidental defects.

### QUESTIONS ON DIVISION 7

**1.** When should the conductors be installed in the conduit? Give the "Code" rules on this question.

**2.** What two methods of installing conductors in conduit are employed? Describe each.

**3.** Define the term *fishing* as it is used in connection with conduit wiring. Is fishing always necessary and why?

**4.** Describe the process of fishing. Should some conduit runs be fished in a certain direction? If so give this direction and explain the reasons why it should be used.

**5.** Why does the pulling-in of a conduit run immediately follow the fishing? What arrangements should be made before starting?

**6.** In what lengths is branch circuit wire purchased? What is the use of different colored braids?

**7.** What are the advantages of using reels for carrying coils of circuit wires? Which type of reel is to be preferred?

**8.** Explain in what lengths large feeders should be ordered. What should be done with the large cable reels?

**9.** Give and explain the six methods of clearing obstructions from the interior of the conduit.

**10.** Give and explain the three general methods of fishing conduits.

**11.** What are the various lines or wires which may be used for fishing? State the advantages of each.

**12.** Explain how the contour of the conduit run affects the cost of fishing and pulling in.

**13.** What is meant by one-way and two-way fishing?

**14.** Give three methods of rounding the end of a fish wire and explain each.

**15.** Is a long-radius curl on the end of a fish wire of any advantage and why? How may a guide tube be used advantageously?

**16.** Is lubrication of the fish wire of any advantage? What lubricant may be used and which ones should not be used?

**17.** Describe three methods of hooking the two fish wires together in double-end fishing.

**18.** How may a large-diameter, comparatively straight conduit be fished?

**19.** Draw a sketch of a device for straightening a fish ribbon and describe how it is used.

**20.** Explain the method of pneumatic pressure fishing. What are its advantages and disadvantages? Describe the details of an improvised outfit.

**21.** Describe the pneumatic vacuum fishing method and give its disadvantages as compared with the pressure method.

**22.** Explain the operation of a conduit fishing machine which forcibly impells the fishing ribbon through the conduit.

**23.** Name four kinds of pulling-in lines and give the particular uses of each.

**24.** Give the principal requirement of a good attachment of conductors to a pulling-in line.

**25.** Describe two methods of attaching conductors to a steel fishing ribbon.

**26.** Describe and illustrate two methods of attaching a rope pulling-in line to a fish wire. Describe two methods, one when the pulling-in rope is provided with a loop and the other when it is not so provided of attaching conductors to a rope pulling-in line.

**27.** Give a method of attaching a group of small conductors to a pulling-in line.

**28.** When more than two conductors are pulled into a conduit, why should each pair of conductors be identified? Explain three methods of so identifying the ends of the conductors.

**29.** Draw a sketch of a device for removing water from a conduit.

**30.** Why should the conductors be lubricated when they are being drawn into the conduit? What lubricant is the most desirable and why?

**31.** How great a force should be required to pull in conductors? Explain the process of "feeding in" the conductors.

**32.** What is the best method of gripping a fish wire?

**33.** Give the common method of pulling-in heavy conduit runs.

**34.** Describe three methods of pulling-in conductors with a crane. Should the rope be attached to the crane hook or the bridge and why?

**35.** What is the function of a guide block? For what other purpose may it be used?

**36.** When tap-off conductors are drawn in with through conductors how should they be attached to the pulling-in line?

**37.** Describe three methods of supporting vertical conductors.

## DIVISION 8

## "TESTING OUT," SPLICING, AND TAPING CONDUIT WIRING

**289. The Steps Which Follows The Installation Of The Conductors In The Conduit,** as explained in Div. 1, consists of connecting the conductors to each other, to the wiring devices (Sec. 10), and to the energy-consuming equipment such as luminaires (lighting fixtures), motors, and the like. But before such connections can be made, in many cases it is necessary to *identify* the conductors (Sec. 290) at each conduit case. It is intended to show in this division how conductors may be identified, how connections should be made, and how wire connections should be insulated.

NOTE.—THE "TESTING OUT" OF THREE-WAY AND FOUR-WAY SWITCH CIRCUITS is discussed quite fully in the author's "Lighting Circuits and Switches." The reader is therefore referred to that book for a more extensive treatment of "testing out" than is given herein.

**290. To "Identify" The Conductors,** as the term is here used, means to ascertain, in some manner, which are the two ends of a given conductor or pair of conductors. After the conductors have been pulled into the conduit, any number of conductors may emerge at a given conduit case. Since each of these conductors must, in order to provide the desired circuits, be attached at some certain point in the circuit, it is necessary that one ascertain accurately, before making connections, which are the two ends of a given conductor or pair of conductors.

NOTE.—WHEN EACH CONDUIT CONTAINS ONLY TWO CONDUCTORS, IDENTIFICATION OF EACH OF THE CONDUCTORS OF THE PAIR IS SELDOM NECESSARY. It may be necessary in such cases to ascertain at distribution cabinets which conduit feeds a given branch circuit but further identification than this is seldom (if ever) necessary for simple circuits. If polarity wiring (Sec. 293) is employed, the colors of the insulation will serve to identify each of the two conductors. If polarity is not being

considered, then each of the two wires need not be individually identified so long as both ends of a given pair of conductors are known—as will automatically be known when there are not more than two wires in any conduit.

**291. Before Identifying The Conductors, The Wireman Should Know Exactly How To Connect The Conductors To Form The Desired Circuits.**—That is, he should have a wiring diagram of the circuit he wishes to execute. For circuits which have but one-location controls, the circuit diagram is very simple and all good wiremen can formulate the diagram without writing it down, and carry the diagram in their minds. But for circuits which have multi-location controls, it will generally pay the wireman to draw a working sketch of the wiring connections he wishes to make. For this purpose great help can probably be obtained from the author's "Lighting Circuits and Switches." Having the circuit diagram, either on paper or in one's mind, it is then a simple matter to ascertain which is the proper conductor to connect between two points.

**292. The Methods Of "Testing Out" Or "Tracing" Conductors In Conduit Systems** are, in general, but three: (1) *By the use of marked conductors* or, what is essentially the same, by marking the conductors as they are pulled into the conduit. (2) *By pulling* (Fig. 579); this is a mechanical means of identifying conductors and will be explained in following sections. (3) *By electrical signaling* as with a magneto, battery and bell or buzzer, or battery and telephone receiver. It is difficult to state which of the three methods is

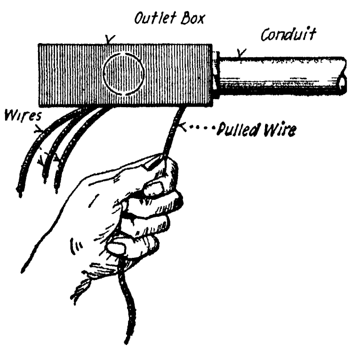


FIG. 579.—"Testing out" or "tracing" conduit conductors by pulling.

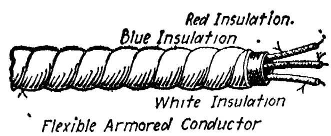


FIG. 580.—Color "markings" of flexible armoured conductor enable conductors to be readily "traced"

best to use—good electricians may be found who adhere to each. The signaling method, although many electricians avoid its use, is certainly the most positive.

NOTE.—THE IDENTIFICATION OF CONDUCTORS BY MARKING is really not a method of testing out but is rather a method of avoiding the necessity of testing out. If, when the conductors were pulled into the conduit they were properly and carefully marked, the wireman may proceed with the connecting up without any preliminary testing out. The conductors of armored cable (Fig. 580) generally bear different colored insulations for their identification. Methods of marking conductors while pulling in are treated in Div. 7.

**293. Identified Or Marked Conductors Should Be Employed** for the neutral wire of all three-wire systems and for

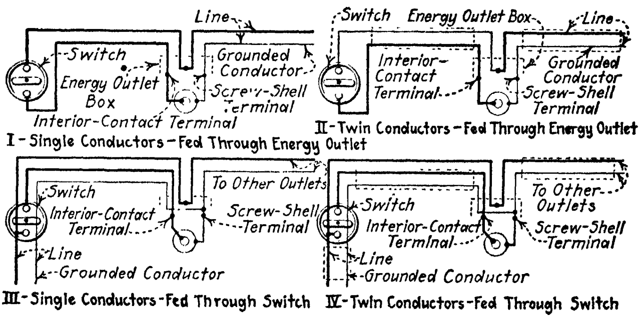



FIG. 581.—Polarity wiring for single-pole switch circuits.

one wire of all two-wire systems, especially for conductors of No. 8 size and smaller (B. & S. gage). The marking should consist of a raised coarse thread in the braid on one conductor, or the braid of one conductor should be finished to show a color which is readily distinguishable from the usual black of weatherproof saturating compounds. For rubber-covered wire the identification shall consist of a white or natural gray covering. This scheme of marking conductors is known as *polarity identification.* The use of polarity-identified conductors often makes testing out unnecessary where only one circuit is carried in a conduit.

NOTE.—METHODS OF WIRING LIGHTING CIRCUITS WITH POLARITY IDENTIFIED CONDUCTORS, as required by the Chicago Electrical Code, are illustrated in that code. Although different schemes of polarity

wiring from those required by the Chicago code could be devised, it seems best to aim toward standardization in this respect. Hence it is here recommended that all polarity wiring be done in accordance with the requirements of the Chicago code. The circuit diagrams shown in Figs.

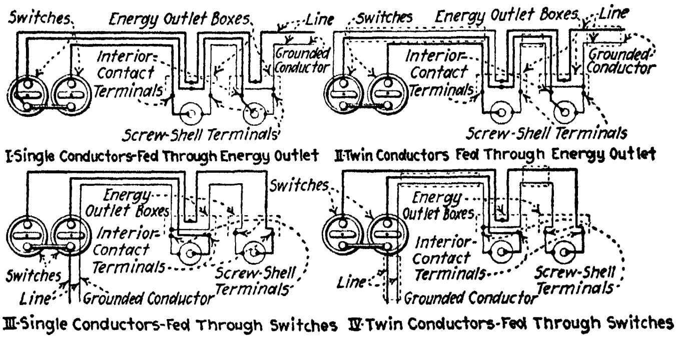



FIG. 582.—Polarity wiring for two-gang single-pole switch circuits.

581, 582, and 583 serve to illustrate the Chicago method of making connections by using polarity-identified conductors. In Figs. 584 and 585 are shown the connections for three-location control and master circuits. In these diagrams the fine lines indicate the "identified"

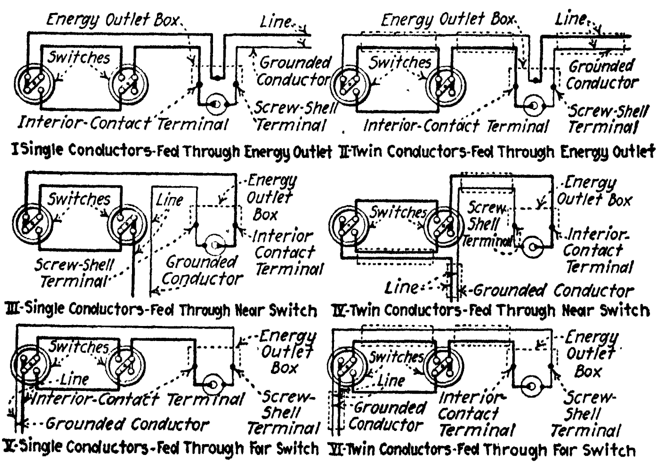



FIG. 583.—Polarity wiring for three-way switch circuits.

conductor (colored) which shall (in the cabinets) be connected to the "grounded" service wire (Div. 9); the heavy lines represent the unmarked (black) wire which shall (in the cabinets) be connected to the ungrounded (hot) service wire or wires. Note that the screw shells of all sockets

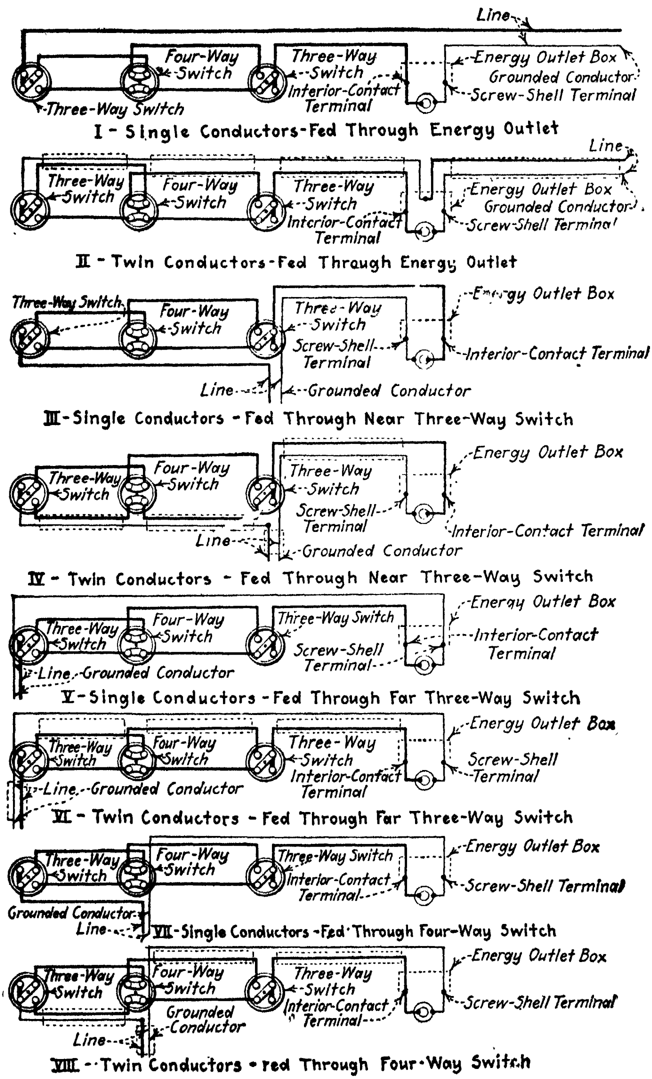



FIG. 584.—Polarity wiring for three- and four-way switch circuits.

shall be connected to the identified (grounded) wire. Also, as indicated in Figs. 581, 582, 583, 584, and 585, single-pole, three-way, and four-way switches must not be connected into the circuit in the grounded wire.

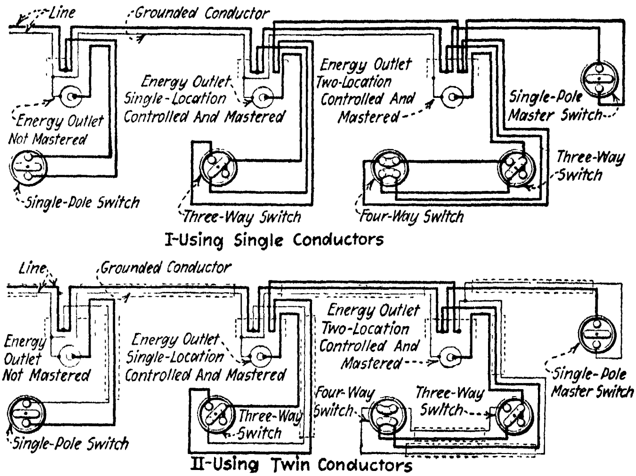



Fig. 585.—Polarity for a combined mastered and unmastered circuit.

**294. The Identification Of Conductors By "Pulling"** (Figs. 579 and 586) consists of giving certain conductors a

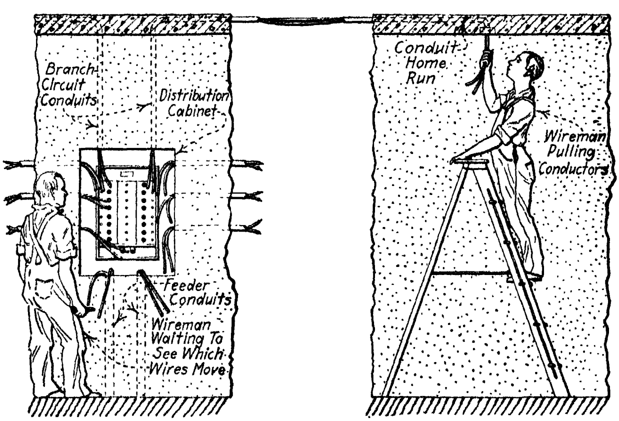



Fig. 586.—Illustrating the method of identifying wires by "pulling."

jerk at one end while helper watches at the other end of the conduit run to see which conductors move. The identifica-

tion is confirmed by the wireman and the helper both pulling and clearing the identified wire. This method of identification is especially suited to "connecting up" at distribution cabinets where certain circuits are to be controlled by given cutouts or switches. Unless all of the conductors which connect to the panel board have been differently marked, some such means of identification must be employed. The pulling method is often more quickly accomplished than is identification by electrical methods. When more than one pair of wires enter a cabinet through one conduit, however, it may be difficult to move one pair of conductors without moving others. Furthermore, care must be exercised to avoid pulling the far ends of the conductors into the conduit.

EXAMPLE.—Assume that, in the wiring of a certain hotel building, it is necessary to arrange the connections so that rooms 19 to 21 on each floor shall be on the circuit numbered 7 at the distribution cabinet on that floor In the layout of the conduit, the home run of this circuit was carried from the distribution cabinet box to, say, the ceiling outlet in room 20. In connecting up this circuit at the panel box, the foreman sends his assistant to room 20 telling him to pull (Fig. 586) on the knotted wires which hang from the conduit. (The home-run wires were knotted when the conductors were pulled into the conduit.) The foreman watches the loose wires at the distribution cabinet until he sees a certain pair move. He then signals to the assistant to "come this way." The assistant understands this to mean that he, in turn, is to watch the wires to see if the foreman has correctly identified the wires. If the wires which the assistant has previously pulled are now seen to move, he signals "all right." If the wires do not move he signals "not yet" or "no." The foreman then knows that he has made a mistake and calls "pull again." This procedure is followed until the foreman gets the "all right" signal. He then connects the identified wires to the connecting screws at circuit number 7 on the control panel.

**295. "Testing Out" By Electrical Signaling** consists of establishing electric circuits through the conductors which are being identified or traced. The usual scheme involves the use of some source of low voltage, such as a dry cell or a magneto, together with some signaling device such as a vibrating bell, buzzer, or telephone receiver. A neat arrangement of testing apparatus (often called a "test set") is shown in Fig. 587. If desired, however, the battery or magneto may be used separately of the signaling device as shown in Fig.

588. When the desired circuit is established, the fact is made known by the signal—that is, the bell will ring, the buzzer will buzz, or the receiver will give a "click."

EXAMPLE.—Two outlet boxes which are connected by a run of conduit containing four wires are shown in Fig. 588. If it is merely desired to identify both ends of any two of the wires, the bell may be fastened to

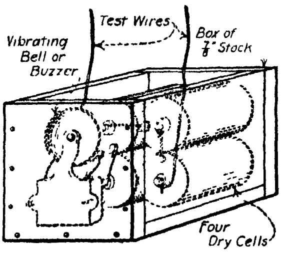



FIG. 587.—Test set for tracing out conduit circuits.

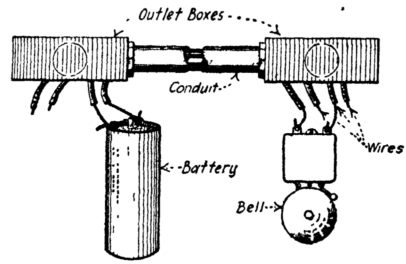



FIG. 588.—Testing out, using a "copper" test circuit.

two of the wires at one end as shown and the battery may be tried on the wires at the other end, two at a time, until the bell rings. In this way, one only ascertains which two wires form a pair—it is not determined which are the two ends of one of the wires.

Should it be necessary to "trace" each wire individually, this may be done by connecting both one polarity of the battery and one post of the bell to the conduit, as shown in Figs. 589 and 590. Then the remaining

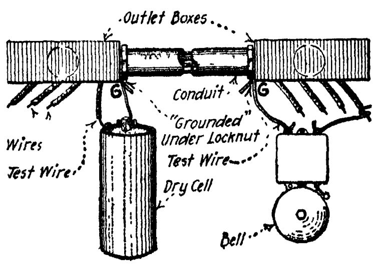



FIG. 589.—Testing out using a conduit-return test circuit. Test wires are "grounded" (connected to the conduit) at $G$ and $G$.

binding post of the bell is connected with one of the wires within the conduit and the remaining polarity of the battery is attached successively to the wires at the other end until the bell rings. By this method one is quite sure that he has found the two ends of a given wire. Another method of tracing the individual conductor is shown in Fig. 590. This method is applicable to the use of a test set. In testing out electrically, *it is very important that no wire ends are allowed accidentally to touch the conduit system.*

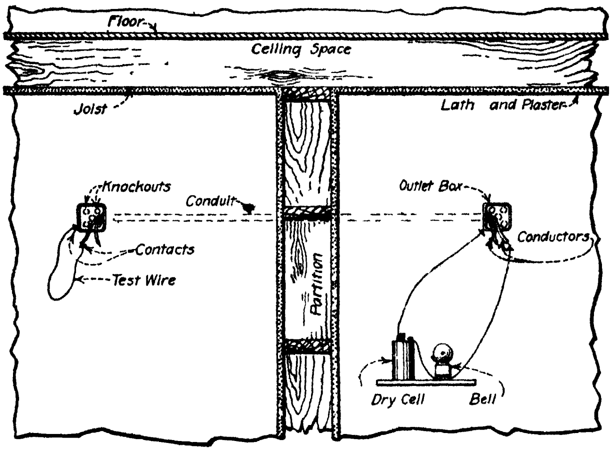



FIG. 590.—Illustrating method of using test set.

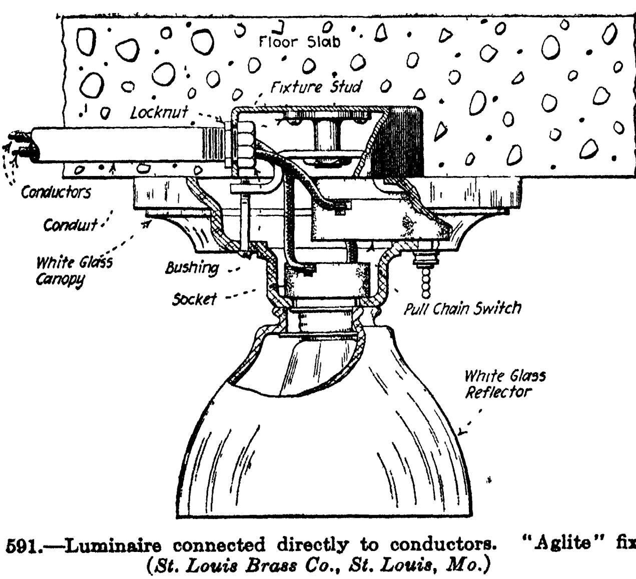



FIG. 591.—Luminaire connected directly to conductors. "Aglite" fixture. (*St. Louis Brass Co., St. Louis, Mo.*)

**296. As Soon As A Conductor Is Identified, It Should Be Marked Or Connected Properly.**—If the device or wire to which a conductor shall connect (Figs. 591 and 592) is already at the conduit case or may conveniently be placed there, it is wise to make the connection immediately after identifying the conductors. If, however, it is impractical to make certain connections immediately, the ends of the conductors should be marked, either with tags, or in some other manner, so that no mistake can be made when it becomes time to make the connections.

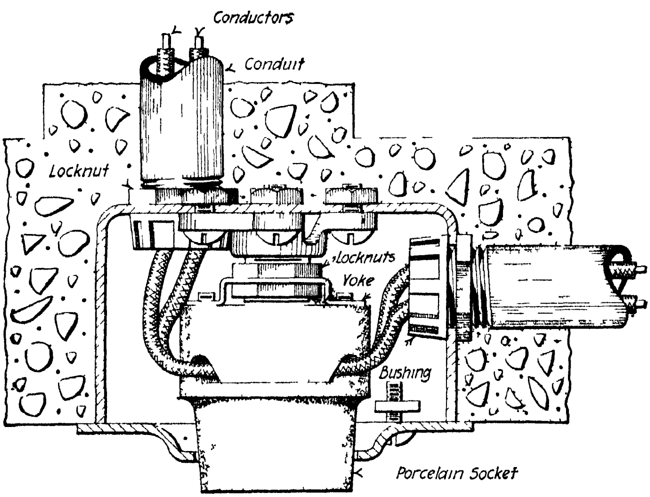



FIG. 592.—Porcelain socket installed in conduit box (*Pass & Seymour* socket No 595 installed in a 4-in deep octagonal box with a raised cover having a $1^{19}/_{32}$-in opening Socket is mounted on fixture stud on a P. & S. No 1160 yoke )

**297. To Make An Electrical Connection Between Two Or More Conductors,** either one of three approved methods may be employed: (1) *A "no-splice block"* (Fig. 593) or its equivalent may be used. The connection is made by fastening a bared end of each of the several conductors which are to be connected under binding screws which are electrically connected by being screwed into one metal piece. (2) *A "solderless connector"* (Figs. 594, 595, and 596) may be used. Solderless connectors are made in many forms, some being covered with an insulating material, others being of metal

and uninsulated. When the uninsulated type is used, it must be insulated by taping (Sec. 300). (3) *The conductors may*

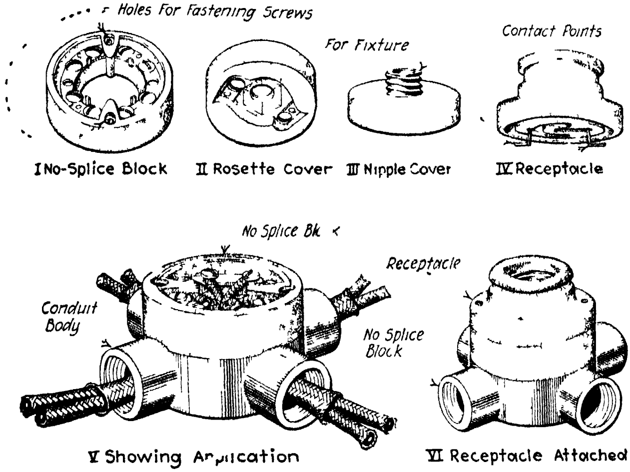



FIG 593.—The "No-Splice Block" which may be used to eliminate the necessity of making splices. (*V. V Fitting Co.*)

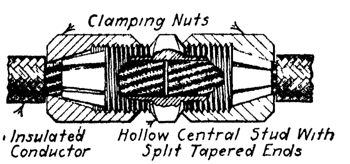



FIG. 594.—A "solderless" connector for wire or cable (*Frankel Connector Co*)

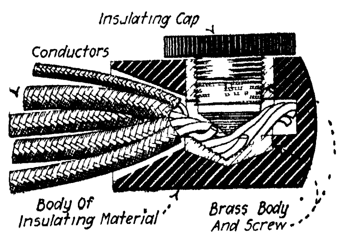



FIG. 595 —The "Usem" insulated connector.

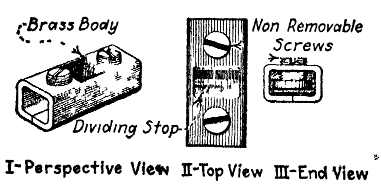



FIG. 596.—The *Sherman* wire connector (will hold two No 12 or three No. 14 wires at each end).

*be "spliced" and soldered* (Fig. 597). The splicing of conductors is further treated in succeeding sections.

Note.—The Use Of Solderless Connectors Is Very Desirable and is recommended by the 1923 Code. Joints can be made with solderless connectors in such short time that the saving in labor will usually offset the cost of the connectors. Furthermore, the solderless connectors become very convenient when, at a later time, it becomes necessary to break or change wire connections when testing or for other reasons.

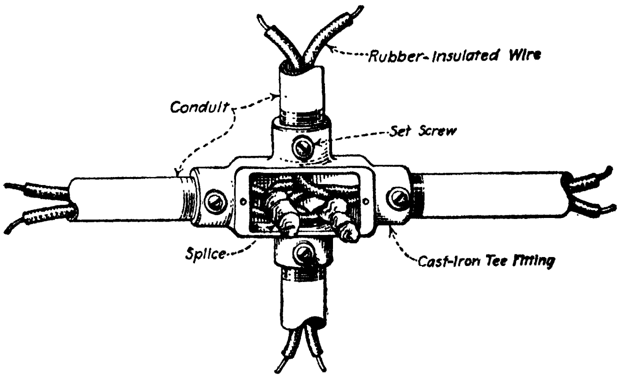



Fig. 597.—Splices in conduit wiring in a tee fitting.

Note.—Lugs Are Sometimes Used For Joining Conductors (Fig. 598). This method is desirable for large conductors which may have to be disconnected in the future for testing or in locating trouble. It is seldom used for small conductors, for which connectors similar to that of Fig. 596 are best adapted.

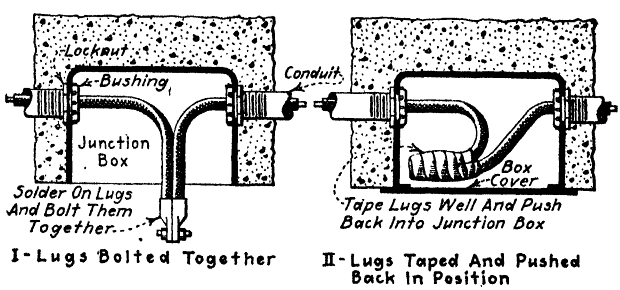



Fig. 598.—Joining conductors by soldering lugs on them and bolting the lugs together. To simplify the illustration, only one wire is shown in each conduit.

**298. Methods Of Making Splices In Conductors** are described in detail in the author's "American Electricians' Handbook" and will not again be given here. However,

since the *rat-tail splice* is extensively used in conduit wiring, its formation is described in the following note. The rat-tail splice is satisfactory for such joints as will not be subjected to great strain.

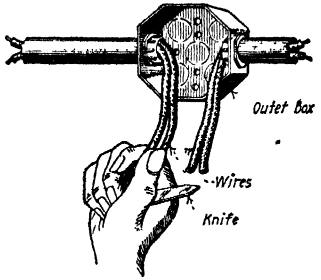



FIG. 599.—Wires drawn out of box preparatory to making a splice.

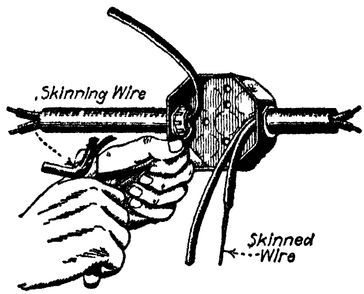



FIG. 600.—"Skinning" the wire for a joint.

NOTE.—THE PROCEDURE IN FORMING A RAT-TAIL SPLICE is as follows: With the wires protruding from the conduit case (Fig. 599), select the two wires which are to be spliced and "skin" the insulation from their ends (about 2 in. on No. 14 wires) and scrape the bared ends of the wires (see Fig. 600). The wires may then be twisted together with the fingers

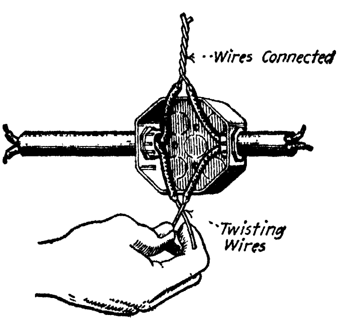



FIG. 601.—The first twisting of the wires for a rat-tail splice.

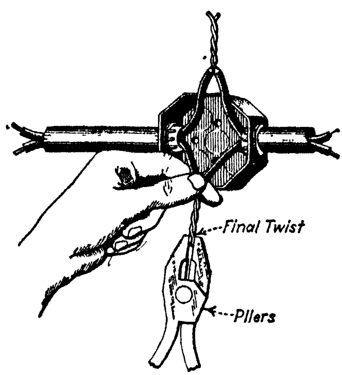



FIG. 602.—Giving a rat-tail splice the final twist.

as shown in Fig. 601. The connected wires should then be given a final twist with the pliers (Fig. 602) to insure that the ends are well twisted. The joint is now ready for soldering (Sec. 299). To permit a neater job of taping (Sec. 300), it is well to pare the insulation to a tapered or pencil-point end as is shown in the illustrations.

**299. The Methods Of Soldering Conductors** are, in general, three: (1) *With a flame;* the conductors are heated with the flame from a gasoline (Fig. 603) or alcohol (Fig. 604) blow-torch until a piece of soldering wire which is being held against

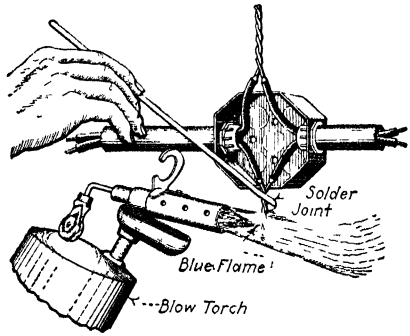



FIG. 603.—Soldering a joint with a gasoline blow-torch.

the conductors melts and flows onto them. In emergencies a candle flame may sometimes be used instead of a blow-torch flame. (2) *With an iron* (Fig. 605); a hot soldering iron is used simultaneously to heat the conductors and melt the

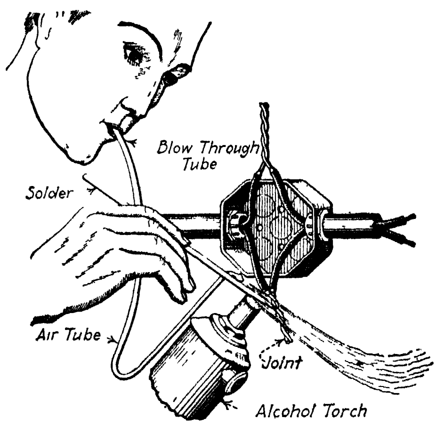



FIG. 604.—Soldering a joint with a small alcohol blow-torch.

solder. (3) *With a ladle* (Fig. 606); the solder is melted in a ladle which is then held up to the conductors so that the joint dips into the solder. This is perhaps the most satisfactory, although it is the most cumbersome, method of soldering splices.

NOTE.—BEFORE APPLYING SOLDER, EACH JOINT SHOULD BE COATED WITH A SOLDERING FLUX. The flux will serve to exclude the air during the soldering and thus insure a stronger joint. Soldering flux may be procured in liquid, paste, or stick form (formulas are given in the author's "American Electricians' Handbook"). The paste form is most generally used; Fig. 607 illustrates its application.

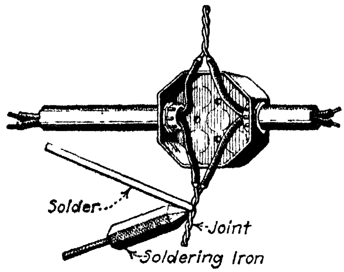


FIG. 605.—Soldering a joint with an "iron" or soldering copper.

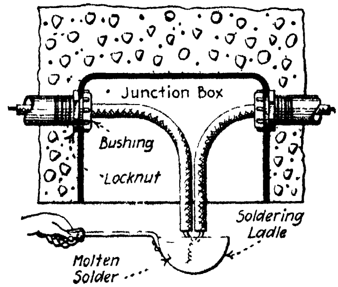


FIG. 606.—Soldering with ladle. To solder the splice, the ladle is raised up so that the joint will dip in the solder. At first, a thick coat of solder will stick to the wire. This indicates that the joint is not sufficiently hot. Continue raising and lowering the ladle until the solder runs freely from the joint, leaving a thin coat on the wire without lumps or drops

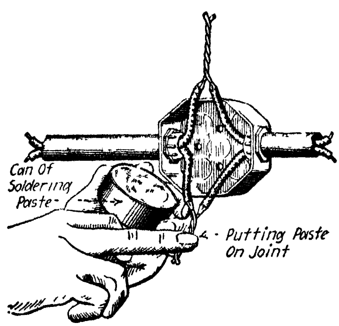


FIG. 607.—Showing method of applying paste to a joint in the wire.

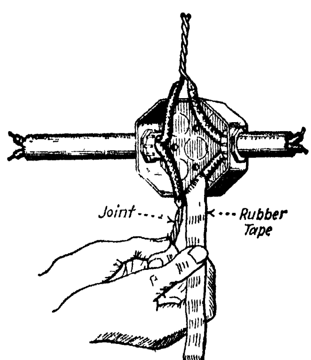


FIG. 608.—The first step in taping a joint.

**300. Electrical Connections Must Be Taped Wherever The Connection Is Not Otherwise Insulated.**—"No-splice Blocks" (Fig. 593) and several of the solderless connectors

are furnished with an insulating covering. All other connections between conductors must, however, be insulated by

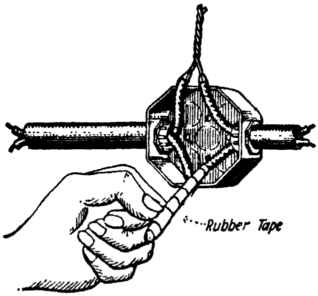



Fig. 609.—Finishing the application of rubber tape. Note that all metal has been covered.

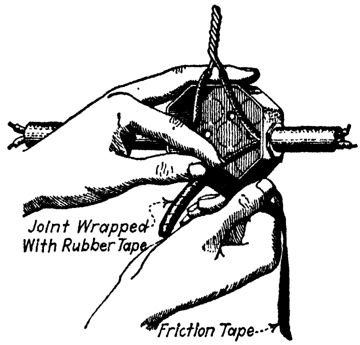



Fig. 610.—Starting the application of friction tape to a wire joint.

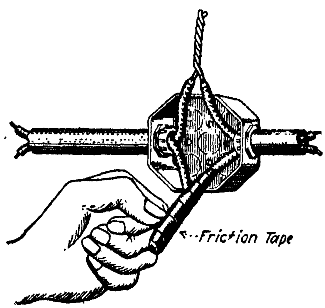



Fig. 611.—"Finishing up" a taped joint. Friction tape covers all rubber tape.

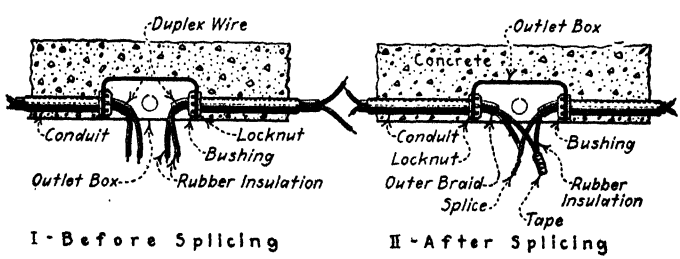



Fig. 612.—Showing method of splicing duplex wire in a conduit installation.

taping. The procedure consists simply of wrapping the exposed metal of the joint first with a covering of rubber tape equal

in thickness to that of the regular insulation of the conductor (Figs. 608 and 609) and then with about two layers of friction tape to protect the rubber (Figs. 610 and 611). In applying the rubber tape, the tape should be stretched to about half its original width and, after the joint is covered, it should, if necessary, be heated for about a minute with a match or spirit flame or with the hand to cause the tape to stick. Tape of ¾-in. original width is generally used. A twin conductor may be taped as shown in Fig. 612.

## QUESTIONS ON DIVISION 8

1. What is the step that follows the installation of the conductors in the conduit?
2. What is meant by *identifying* the conductors in a conduit-wiring system? Why is it necessary?
3. Is identification of conductors necessary when only two conductors are carried in each conduit? Explain fully.
4. What should a wireman know before beginning to identify the conductors in a conduit-wiring system? Need this information in all cases be written down? Explain fully.
5. List the three general methods of identifying conductors. Which method is the most certain in results?
6. In what way does the identification of conductors by marking differ from the other two methods?
7. For what purposes should marked or identified conductors always be used? What is the proper marking of the conductors for these purposes?
8. Discuss the question of *polarity wiring*.
9. Draw from memory the polarity-wiring diagrams for single-pole and three-way switch circuits with the outlets being fed through the energy outlet box and through the switch boxes in each case.
10. Describe briefly the method of identifying conductors by pulling. Give the advantages and disadvantages of this method.
11. Formulate an example to illustrate the method of identifying conductors at a distribution cabinet by the pulling method.
12. What is the fundamental principle of identification of conductors by electrical signaling? Name two kinds of voltage-source and three kinds of signaling devices which may be used.
13. Explain in detail, by formulating an example, how wires may be identified by electrical signaling. Draw a sketch.
14. After a given wire has been accurately identified what should be done next? Explain.
15. Explain the three methods of making connections between two or more conductors.
16. What are the advantages of "solderless" connections? Are they approved by the underwriters?
17. What form of splice is widely used in conduit wiring? Explain, with sketches, the method of making this splice.
18. Explain the three methods of soldering joints in conductors. Which method is the best?
19. What is the purpose of a soldering flux? In what forms are soldering fluxes obtainable? Which is most used?
20. Under what conditions must a connection between electrical conductors be taped?
21. Explain the procedure of taping a spliced joint.

# DIVISION 9

## GROUNDING CONDUIT SYSTEMS

**301. The Conduit System Should Be Effectively Grounded** to minimize the fire hazard of accidental grounds. When conduit systems are installed, it is impractical to insulate them from the earth. At various points, they will contact accidentally with objects which are connected to the earth, such as gas pipes, water pipes and damp timber. The accidental grounds thus formed develop fire risks in one of two ways: (1) *By arcing.* (2) *By short-circuit.*

**302. Arcing** (see following explanation for conditions under which it occurs) is more hazardous than the short-circuit because the arcing occurs on the outside of the conduit and may continue for some time, thus creating considerable heat. Also if inflammable material is near the arc, it may be ignited.

**303. Short-Circuits** between the conduit and a "live" conductor or between the conduit and a grounded conducting object, are not, when the circuit is properly fused, as dangerous as arcs. When the circuit is properly fused the large short-circuit current blows the fuse and thus flows for only an instant.

**304. By Effectively Grounding The Conduit, A Short-Circuit Instead Of An Arc Will Be Produced,** should the conduit touch a conductor of different potential than the ground. Thus by "effectively" (through a good contact of low resistance) grounding the conduit, the fire hazard is greatly reduced. It is for these reasons that the "Code" requires that all metal parts of the conduit system be electrically connected and effectively grounded, through connections of low resistance.

EXPLANATION.—Assume that one "live" conductor within the conduit becomes bared and makes contact (*A*, Fig. 613) with the conduit or with any fitting joined to it. Also assume that the other conductor

of the same system but of different potential is already or becomes grounded, as at $G$. Then, a circuit is formed through each of the various connections to earth (Fig. 613). In each of these connections a current tends to flow. The one ground at $A$, on the one side of the circuit, should not of itself make trouble, provided there were no ground at $G$ on the other side. In practice, however, there is nearly always a ground on either side of the system. In fact, one wire of alternating-current secondary circuits and the neutral of a direct-current three-wire system should, in practically every case, be grounded as specified in the "Code." This is done to minimize the life hazard; see author's "Wiring for Light and Power" for a discussion of this practice.

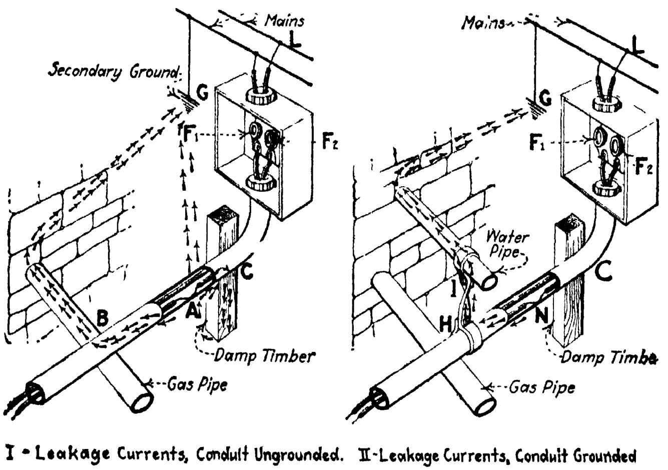



FIG. 613.—Path of leakage current flowing in grounded and ungrounded conduit systems.

Now, the intensity of the currents which flow through the ground will vary with the resistance of the circuits concerned. The ground contact may (unless the conduit is intentionally grounded) have such high resistance as through $ABG$ and $ACG$ (Fig. 613) that the short-circuit current flowing will not be great enough to operate the fuse, but it may be large enough to produce an arc. Such arcs may develop at poor connections (as between conduit and ground and between poorly connected lengths of conduit). These arcs may continue for a considerable time, because the fuse will not be blown. Also, these arcs may cause excessive heating or, if near inflammable materials, may ignite them. For example, if the ground is a gas pipe, the arc may burn a hole in the pipe and possibly ignite the gas.

Now, when the conduit is permanently and effectively grounded, as at $HIJ$ (Fig. 613), and one of the conductors of the system accidently contacts with the conduit as at $N$, the resistance of the contact and the ground path is low. Hence, a large current will flow through the circuit

$LF_2NHIJG$. This heavy current would almost instantly operate the cut-out, $F_2$, disconnecting the location of the trouble from the source of current. This short-circuit when the conduit is "effectively" grounded will not likely lead to serious trouble since the heating caused by the instantaneous flow of large current is negligible.

**305. When There Are Two Or More Separate Parts To A Conduit System** that are not mechanically connected they should be electrically connected by means of conductors or each part must be grounded separately. Short lengths (under 25 ft.) of conduit or pipe which are used for the protection of exposed wiring on walls need not be grounded. Conduit service entrances need not be grounded: (1) *When* they are guarded if within reach from grounded surfaces. (2) *When* they are insulated from the ground and metallic parts of the building.

NOTE.—WHEN INSTALLING CONDUIT, ALL JOINTS SHOULD BE GOOD ELECTRICAL CONNECTIONS. High-resistance joints will reduce the protection against fire and shock which the grounding was provided to insure. They are also likely to cause arcing and overheating at the joints. When enameled conduit is employed, especial care should be taken to remove the enamel from the threads of both the conduit and the coupling. The enamel is an insulator and may prevent a good electrical connection between the conduit and the coupling (see also Sec. 170).

**306. Ground Conductors Differ In Function From The Circuit Wiring Conductors** in that the ground conductors ordinarily carry no current. Consequently ground conductors do not affect the normal operation of the lights, appliances, or motors. It thus follows that the ground connection may be broken or disconnected and that the break will escape notice until the emergency arises for which the ground connection was installed to furnish protection. Furthermore, the ground wire must often be run in places not usual for circuit wires. Hence it is more subject to corrosion and mechanical injury than the circuit wires. For these reasons, it is necessary to take special precautions when installing ground conductors.

NOTE.—THE GROUNDING INSTALLATIONS ON THE CIRCUIT-WIRING SYSTEM are similar to those on the conduit system. The probability of the circuit-wiring ground conductor carrying a current is greater than that of the conduit-system ground conductor carrying one. For

this reason the circuit-wiring ground requirements are a little more exacting than those for the conduit system ground. Where the requirements differ, the differences are given in the following sections.

**307. The Ground Conductor Should Be Installed** with the same precautions that would be taken if it were a circuit wire. Thus, if the ground conductor is installed as open wiring, which is the usual method, all the rules pertaining to open knob-and-tube wiring, such as proper spacing from woodwork and support on knobs, must be observed. These precautions are necessary because in an emergency the ground conductor may be called upon to carry a heavy current, large enough to overheat it seriously. Hence, if it is carefully installed, the likelihood of fire is reduced.

**308. The Ground Conductor Should Also Be Of A Certain Current-Carrying Capacity.**—The "Code" requires that the ground conductor for the conduit system should be at least equivalent to No. 10 B & S. gage copper (where the largest wire contained is not greater than No. 0 B. & S. gage) and need not be greater than No. 4 B. & S. gage (where the largest wire contained is greater than No. 0 B. & S. gage) and for service conduits the ground shall not be less than No. 8 B. & S. gage copper. The conductor must be of copper (it need not be insulated) or other metal (a piece of conduit may be used) which will not corrode excessively under the existing conditions, and if practicable must be without joint or splice.

NOTE.—EITHER A WIRE OR A CONDUIT SECTION MAY FORM THE GROUND CONDUCTOR FOR THE CONDUIT SYSTEM (Figs. 614, 618, and 621). In alternating-current systems, two grounds are required (by some inspection departments) at the place of installation: (1) One for the grounded conductor of the wiring system. (2) The other for the metallic conduit system. The "Code" permits the conductors for both of these grounds to be composed of copper wires. The "Chicago Code" requires that the conduit-system ground conductor (for alternating-current systems) be a section of conduit running from the service switch cabinet to the ground (Fig. 614). This conduit must contain a rubber-covered wire which must be connected to and ground the *service* wire (Fig. 614-*I*). The ground conduit and the ground wire therein must be connected to the ground by means of independent ground clamps. A piece of conduit may also be used for grounding equipment, such as motor frames, as shown in Fig. 615.

NOTE.—THE GROUND CONDUCTOR FOR THE CIRCUIT WIRING must be insulated and must be of a larger current-carrying capacity than the

conduit-system ground conductor. For alternating-current systems, the conductor must not be smaller than No. 6 copper wire nor smaller than one-fifth the current capacity of the wire to which it is attached, except that it need not be larger than No. 0 copper wire. For a three-wire direct-current system, the ground conductor must have a current capacity not smaller than the neutral wire to which it is attached.

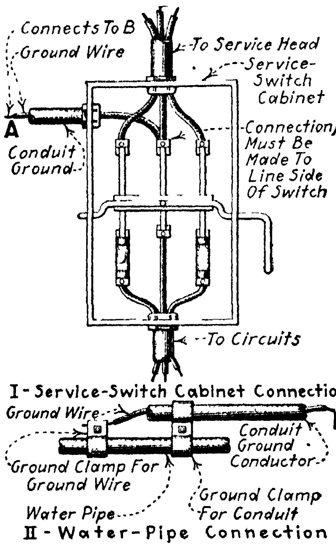



FIG. 614.—Ground for the conduit system and the neutral wire as required by the "Chicago Code." A conduit serves as the conductor for grounding the conduit system and a wire is used for the ground-conductor.

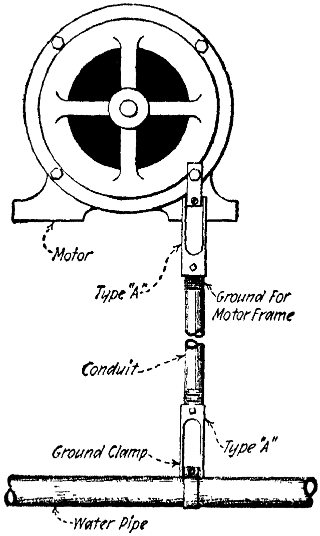



FIG. 615.—Grounding motor frame with a conduit section attached to water pipe. The ground clamps used are known as "Groundits." (They are manufactured by *The Cowles Electric Co., New Britain, Conn.*)

**309. The Ground Conductor For The Conduit System Should Be Separate** from that for the wiring system (Fig. 616-*I*). The practice of splicing the conduit system ground conductor to the wiring system ground conductor (Fig. 616-*II*) is not permitted by the "Code," except under special permission of the inspection department. A short length of wire and a ground connection may be saved by this method but the protection afforded is greatly decreased. It is much more important to have the protection than to save the relatively small length of wire which may be worth only a few cents.

NOTE.—SHOULD THE GROUND CONDUCTOR BECOME BROKEN AT *A* (Fig. 616-*II*), when both conduit and neutral wire are grounded with the same conductor, then the interior conduit system would be raised to the potential of the neutral wire (assuming no other low-resistance grounds existed on the conduit system). The potential of the neutral wire may be different from that of the ground. Thus a voltage would be impressed on the conduit system, in case the ground wire were broken. This might cause a fire or establish an accident hazard.

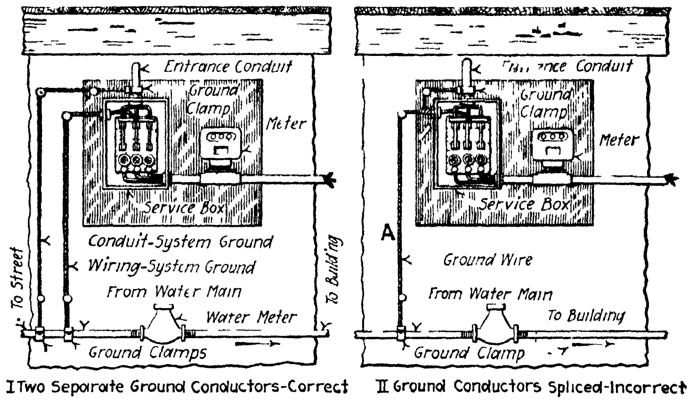



FIG. 616.—Showing correct and incorrect methods of running the two-ground conductors.

**310. The Ground Connection For The Conduit System** should be as near as practicable to the service entrance, that is to the point where the conductors in the system receive their energy supply. The point of attachment should be such, that both the connection and the ground wire are protected from injury and still are accessible for inspection by the electrician or the inspector. The ground wire should be as short as possible. The connection should be permanently and effectively made to a water-piping system if available. When possible, the connection must be made on the street side of the water meter (Fig. 616) unless a long run is required, when it may be made on the inside of the water meter, provided the meter is shunted with a conductor (Fig. 617) and all parts of the system liable to create a hazard are electrically connected. If the connection to a water-piping system would require a long run (over 20 ft.), the ground may be made to the gas-piping system or to an artificial ground

(Sec. 315). Should the gas-piping system be used, it must be bonded to the water-piping system within the building at their points of entrance.

NOTE.—WHEN THE SERVICE CONDUIT IS GROUNDED, its ground conductor should be run direct from it to the ground connection. The

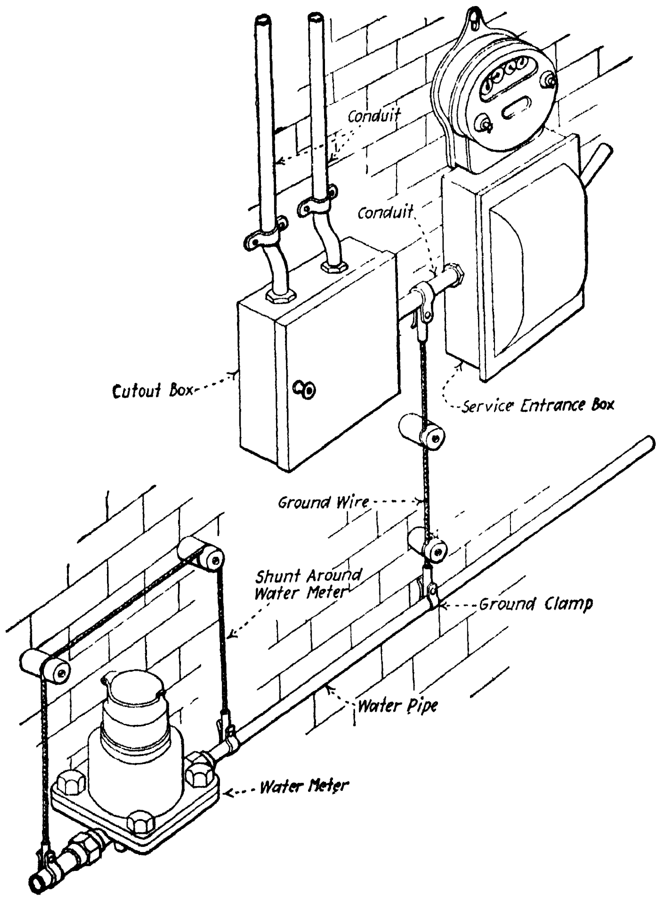



FIG. 617.—Method of grounding conduit system to water pipe on the inside of the water meter.

interior conduit if well bonded (electrically connected triangle conduit, metal boxes or with a conductor) to the service conduit which is grounded as provided above, will require no additional ground. The ground on the interior conduit system shown in Fig. 618 is not required by the "Code" and is seldom employed.

NOTE.—GROUNDING ON THE GAS-PIPING SYSTEM may be employed only for conduit, equipment, etc. It should not be used to ground the circuit-wiring system. When it is used, the ground connection must be made between the gas pipe entrance to the building and the meter.

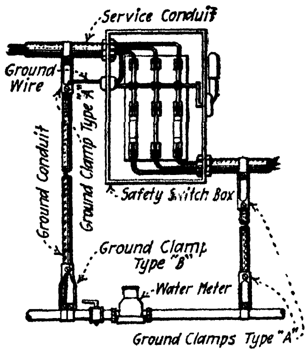



FIG. 618.—A neat method of grounding the conduit system and the neutral wire of the wiring system to a water pipe. The conduit protects the ground wire for the neutral and also serves as a ground conductor for the service conduit. The Type *A* connection has only one clamp, while the Type *B* connection has two clamps, one for the conduit ground and the other for the wire ground. The clamp can be obtained for ½ to 1¼-in. conduit and for pipe sizes of from ½ to 6 in. The ground on the load side of the switch box is not required by the "Code." (Clamp made by *The Cowles Electric Co., New Britain, Conn.*)

**311. For The Ground Connection To A Metallic Piping System,** an approved ground clamp, which is bolted around the pipe (Figs. 619, 620, and 621–*II*), or a brass plug which

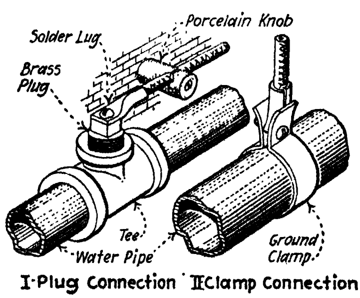



FIG. 619.—Methods of connecting ground wire to a water pipe.

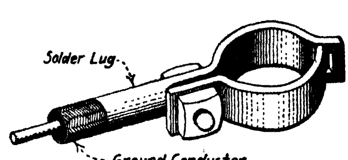
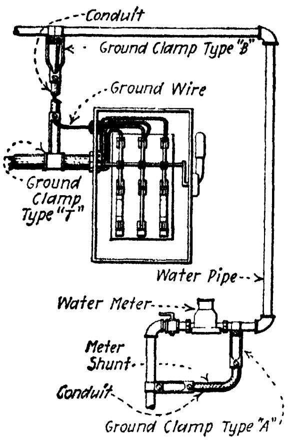



FIG. 620.—Ground clamp. (*Conduit Electrical Mfg. Co., Boston, Mass.*)

screws tightly into a pipe or a fitting (Fig. 619–*I*) should be used. The old-style wire-wrapped ground joint (Fig. 622), provided it affords substantial and reliable attachment, may

be employed. But, as the commercial ground clamps and plugs are inexpensive, it is usually more economical to use one of these than to attempt to make up a good connection. Either a soldered lug or an approved solderless connector should be used for attaching the ground wire to the clamp or plug. It is obvious that the solderless connector requires less time to install.




NOTE.—THE GROUND CONNECTION TO THE WATER PIPE is the most important part of the grounding installation, as it is particularly subject to corrosion, removal, mechanical injury, and loose contact.

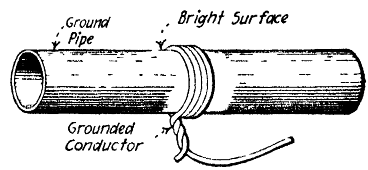



FIG. 621. FIG. 622.

FIG. 621.—Grounding conduit and wire system in back of water meter and using a shunt around the meter. The Type *T* connection includes a coupling which screws into the pipe system, instead of the usual clamp. This type of connector could also be used in the water pipe line. It makes a very secure ground connection. (Made by *The Cowles Electric Co., New Britain, Conn.*)
FIG. 622.—A wire-wrapped ground joint.

Especial care should be taken to make it a good electrical connection, and to place it in an easily accessible location.

**312. Ground Clamps** provides a very satisfactory connection between the ground wire and the pipe system. They are used more extensively on small water pipes and artificial grounds than are the plugs. Usually, no tee is provided in the water-pipe line, and the use of the plug would require cutting the pipe and inserting a tee. Various types of clamps are made which may be purchased for any reasonable size of pipe. The simple type shown in Fig. 620 seems to serve as well as any. In using a clamp, the pipe must be carefully scraped free from rust or scale and the clamps fastened firmly and solidly to the pipe. A good way to prepare the pipe is to place a pair of pliers on it where it is to be cleaned and turn

them around it until the surface is bright. Any ground clamp should be regularly inspected and tightened after standing. This is to take up the stretching of the copper band and the loosening caused by expansion. When the solder-lug type is used, the wire conductor should be soldered to the lug before the lug is attached to the clamp.

NOTE.—THE CURRENT-CARRYING CAPACITY OF GROUND CLAMPS is limited. While the "N. E. C." does not specify any limit nor does it require more than one ground clamp for any connection, the "Chicago Code" does limit the current carrying capacity of the standard clamp to 100 amperes. When the mains are of a current-carrying capacity greater than 100 amperes, it requires that a group clamp be provided for each 100 amperes or fraction thereof of main carrying capacity. For example, assume that mains of 400,000 C.M., which has a carrying capacity of 325 amperes, are installed. In such a case the ground wire for both the neutral and the conduit must each be connected to the water pipe by 4 standard ground clamps.

NOTE.—IN THE CONSTRUCTION OF GROUND CLAMPS, THE MATERIALS (as specified by the "National Electrical Code") may be copper, cast brass, malleable iron, or sheet-steel, except that parts to which soldered connections are made must be of copper or brass. Sheet-metal clamps, if of copper, must have a thickness not less than No. 16 B. & S. gauge (0.051 in.) or, if of steel, must be hot galvanized and not less than No. 16 U. S. gauge (0.062,5 in.) in thickness. The minimum width of sheet-metal clamps to be not less than ¾ in. Clamps, if made of malleable iron, must be hot-galvanized or sherardized in an acceptable manner as a protection against corrosion.

**313. Usually At Least Two Clamps Are Used,** one for attaching the wire to the water pipe and the other for fastening

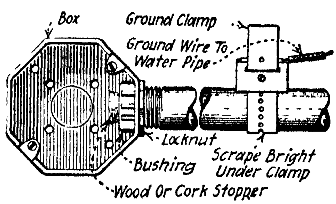



FIG. 623.—Ground clamp connected on conduit.

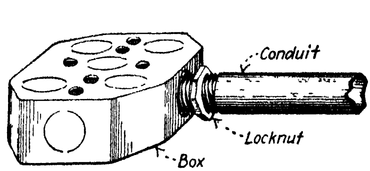



FIG. 624.—Connecting the ground wire with a locknut. *First step,* locknut screwed back and contact faces of box and locknut scraped clean.

it to the conduit (Figs. 617 and 623). The connection to the conduit should be as well made as that to the water pipe. The method of attaching the ground wire directly to the con-

duit between a *locknut and a conduit box* (Figs. 624 and 625), is sometimes employed but cannot be recommended. More time is required for making such a connection than is required for the ordinary clamp attachment. Also it is very doubtful if such a method would be passed by the local inspector.

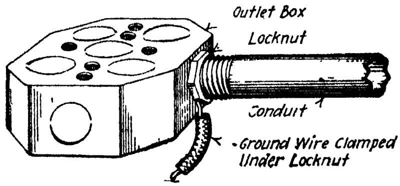



FIG. 625.—Connecting the ground wire with a locknut. *Second step*, loop the ground wire, in correct direction, around the conduit between the conduit box and locknut and then tighten up the locknut. Test the tightness of the ground wire by pulling on it.

**314. A Brass Plug** having a solder lug connection for the ground wire (Fig. 619–*II*) probably makes a better ground connection than does a ground clamp. However, they are not employed as often as they should be because tees for their reception are rarely provided "ahead of the meter" in ordinary water pipes. They are very satisfactory for grounding to large water mains where it would be difficult if not impossible to install a suitable clamp around the pipe. Under such conditions all that is required, when using the plug, is to drill and tap a small hole, in the large mains to accommodate the plug. Then screw the plug therein.

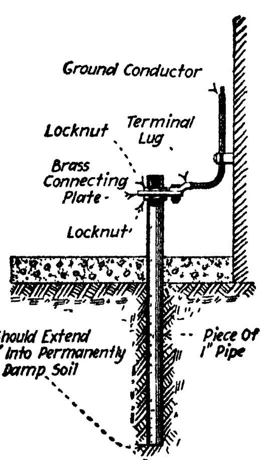



FIG. 626.—Artificial ground made of 1-in. pipe.

**315. Artificial Grounds** (Fig. 626) are seldom employed where water pipes are available because a water pipe earth-connection is more easily and quickly made and is usually better. However, they are used when no water pipes are available. They should be located, where practicable, below permanent moisture level. Each ground must present not less than 2 sq. ft. of surface to exterior soil. The ground may consist of any metallic body which does not

easily corrode. Usually an *iron pipe, conduit, or rod* driven into the ground is used. *Pipe grounds* are most often employed. While they are the cheapest, they are very effective, if properly installed. The disadvantage they have is that they should be inspected at intervals because iron pipe, under certain conditions, rusts away rapidly, particularly at the ground line. The connection of the ground conductor to an artificial ground may be made in the same manner as it is made to a water pipe; that is, with a ground clamp or brass plug, or by a wire-wrapped joint. Other methods of connection (see author's "Wiring For Light And Power") may be used such as clamping a brass plate (Fig. 626) between two locknuts screwed on the threaded end of the pipe.

NOTE.—THE RESISTANCE OF THE PIPE EARTH CONNECTION depends on various factors and conditions. The resistance of the connection will usually vary inversely as the depth of the pipe in the conducting stratum. Nearly all of the resistance is concentrated in the immediate vicinity of the pipe. A salt or charcoal filling, placed around the pipe, will greatly reduce this resistance (see author's "Wiring for Light and Power)." Several pipes connected together (forming a multiple-pipe ground) may be used for the earth connection. The pipes should not be closer together than 6 ft. but should be electrically connected at their tops with a conductor. When so arranged, the resistance of a multiple-pipe ground will vary inversely as the number of pipes composing it; that is, if 4 pipes are employed the combined resistance will be only one-fourth of the resistance of a one-pipe connection. The diameter of the pipe has little effect on the resistance. A 1-in. wrought-iron pipe is usually employed. A good earth connection made by a single pipe driven into the ground should have a resistance less than 20 ohms.

### QUESTIONS ON DIVISION 9

1. Explain why a conduit system should be effectively grounded.
2. Must all conduit be grounded and if not what are the exceptions? What precautions should be taken when installing conduit so that the ground connection is more effective?
3. In what manner does a ground conductor differ from a circuit-wiring conductor? How do the rules which govern their installation differ? Are conduit system grounds similar to the wiring system grounds?
4. Give the rules for installing a ground conductor for a conduit system and for the circuit-wiring system. Of what material must the conductor be in both cases?
5. How many ground wires must be used for both the conduit system and circuit-wiring grounds?
6. Explain how ground connections should be made. Explain as to where they should be connected and the method of making the connection.
7. State the use of a ground clamp and its advantages. Describe the method of installing a ground clamp. How many clamps should be used?
8. Explain the use of a brass plug for a ground connector.
9. When should artificial grounds be used? Describe how they can be constructed and the methods of connecting the ground conductor to them.

## DIVISION 10

## TESTING CONDUIT WIRING FOR CONTINUITY AND INSULATION

**316. After The Installation Of A Conduit-Wiring System Is Completed, The System Should Be Tested** to insure that there are no flaws in the wiring. This should preferably be done before the public service company is asked to connect to the service conductors. By making the proper tests, the wireman can assure himself that: (1) *All connections have been properly made.* (2) *No short-circuits exist in the system. The insulation of no conductor has been dangerously damaged during its pulling-in.* He may then leave a job with the assurance that he will not be called back to correct some fault in the wiring.

NOTE.—EXTENSIVE TESTS FOR CONTINUITY AND INSULATION ARE SELDOM MADE by wiremen. Experience has shown that the occurrence of serious faults, in the wiring of buildings which has been installed by good wiremen, is quite infrequent. Occasionally, a wiring installation may contain a *short-circuit* or a faulty connection, but such errors would scarcely ever lead to serious results. Should the energy be supplied to such a system, about the most serious result that could happen would be the opening of a cut-out (the blowing of a fuse) or the failure of the energy reaching an outlet. Hence the usual practice is to connect the supply wires without first performing tests for continuity and insulation. *Faults* in the system are then detected by connecting a device to each energy outlet and operating the switch or switches which control that energy outlet.

**317. The Order In Which Tests For Continuity And Insulation Should Be Made,** is as follows: (1) *Tests for electrical continuity of the conduit itself* (Sec. 318). (2) *Tests for short-circuits* (Sec. 319). (3) *Tests for continuity of conductors and proper connections* (Sec. 320). (4) *Tests of insulation resistance between conductors and conduit* (Sec. 323). (5) *Tests of insulation resistance between conductors* (Sec. 323).

**318. In Testing The Electrical Continuity Of The Conduit System, In A Conduit-Wiring Installation** (Fig. 627), a good method consists of using the conduit as a return for a signal circuit. A simple method of making connections for this test would be to fasten one end of a long piece of bell wire to the service conduit, *S*, and attach the other end of this wire to one post of a test set, *I* (see Fig. 587). Then carry the test set, with the bell wire attached, in turn to each conduit case in the building which has but one conduit ending at the case

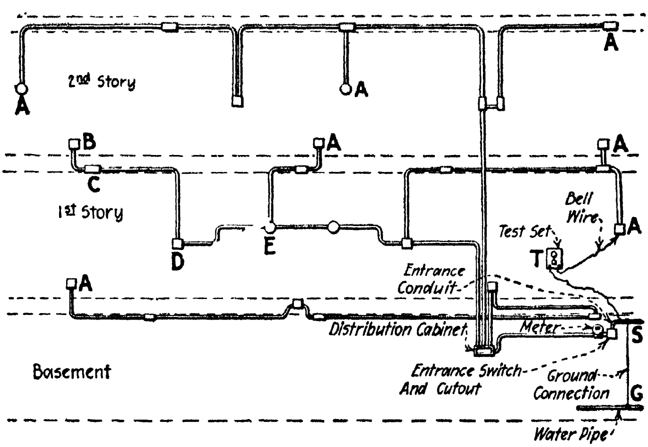



FIG. 627.—Diagrammatic view of conduit wiring in a residence.

(cases *A* and *B*, Fig. 627). To each such conduit case touch a wire which is attached to the second post of the test set. If the conduit system is electrically continuous, the bell or buzzer will respond whenever the wire is touched to any conduit case. If, however, the response is obtained at all of those cases which have only one conduit entering them, then it is certain that the conduit system is electrically continuous to those cases which have more than one conduit end within them.

EXAMPLE.—Assume that in testing the conduit system of Fig. 627, a response is obtained each time that the test set is touched to one of the cases *A*, but not when it is touched to case *B*. This indicates that the conduit system is electrically continuous except between points *E* and *B*. The test set should then be employed successively at cases *D* and *C*. If a response is obtained at *D* but not at *C*, this indicates a

faulty connection of the conduit run *CD* to one of the two cases. This should then be remedied by unscrewing the bushings inside these cases, scraping the enamel from the inside of the cases, and again screwing up the bushings firmly against the side of the case.

NOTE.—THE WATER OR HEATING PIPING MAY BE USED AS A PORTION OF THE SIGNAL CIRCUIT (Fig. 628) for testing continuity of the conduit system. It is evident that, when testing as above directed, a long piece of bell wire must be dragged about the building. To forestall this inconveniece the method of Fig. 628 may be employed (the conduit must, however, be grounded to the water-system piping as at *G* in Fig. 627). Instead of the radiator of Fig. 628, a faucet in a nearby kitchen or bathroom may be used. The conduit system then is connected in series with the water or heating piping and only short lengths of wire are needed.

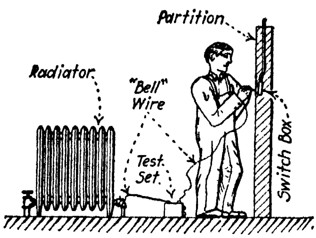



FIG. 628.—Testing continuity of conduit through the heating-system piping.

**319. In Testing For Short-Circuits** (Fig. 629), a good method is to disconnect all energy-consuming devices (unscrew lamps from fixtures, etc.), close all switches and cutouts, and then attach a test set to the service entrance wires. If there are three service wires they may be connected to the test set in pairs, that is, two at a time. Under the above conditions no signal should be received at the test set.

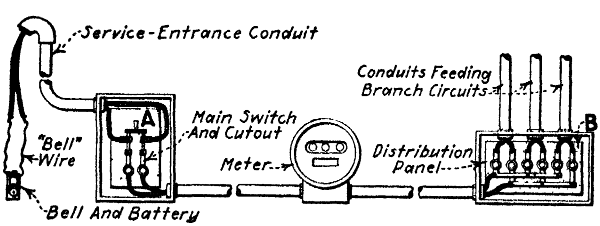



FIG. 629.—Testing for short circuits.

NOTE.—IF A SIGNAL IS PRODUCED, THE SHORT-CIRCUIT CAN BE ALLOCATED by removing fuses along the circuit as follows: Remove the nearest fuses to the service entrance (*A*, Fig. 629). If the signal continues, the short-circuit is in the service conduit. If removing fuses *A* stops the signal, replace fuses *A* and remove all of the fuses on the distribution panel *B*. If a signal is now heard, the short-circuit is between *A* and *B*. If no signal is now heard, replace the fuses on *B* a set at a time until the signal is again heard. The circuit which is fed

by the set of fuses which again started the signal is then the one which contains the short-circuit. By unfastening the splices in this circuit, beginning nearest the fuses, until a point is reached where breaking the conductors does not stop the signal, the location of the short-circuit can be localized to a certain run of conduit. Then, unless the short-circuit can be found in a poorly taped joint or similar place at one end of this run, the conductors in the run must be removed.

**320. To Test For Continuity Of Conductors And Proper Connections,** a very good method is as follows: (1) *See that no energy-consuming devices (lamps, motors, etc.) are connected to the conductors.* (It is here assumed that the wiring has already been tested (Sec. 319) and found free of short-circuits.) (2) *Attach a dry cell across the busbars of the distribution panel, across the main switch, or to the service entrance wires;* for three-wire systems,

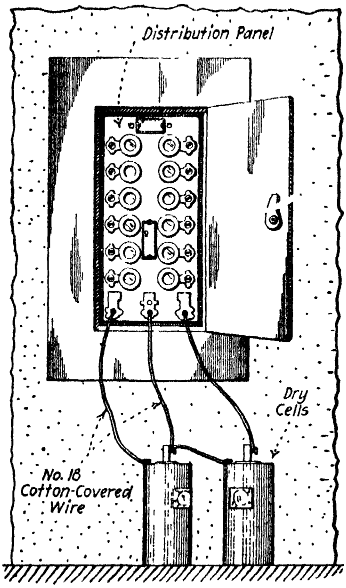



Fig. 630.—Showing how to fasten dry cells to a 3-wire system for testing for continuity of conductors and proper connections.

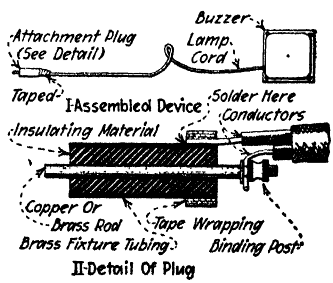



Fig. 631.—Device for testing continuity of circuits to lamp sockets.

two cells may be attached—one to each side (Fig. 630). (3) *Connect a bell or buzzer in turn to the two conductors at each outlet.* If sockets are already attached to the conductors, an attachment plug fastened to a buzzer (Fig. 631) will be found convenient for making the tests. While the bell or buzzer is attached at an outlet, have an assistant operate the switch or switches which control that outlet to see that

they actually control the outlet. If the conductors are continuous, the bell will ring.

**321. The "Code" Makes A Requirement As To Insulation Resistance** ("Code" rule No. 507, see note below). Although the "Code" also specifies that all conductors must have an "approved" insulation, the requirement as to the insulation resistance of the completed installation is necessary to insure that the insulation of the conductors has not been damaged during pulling in. The test for insulation resistance (Sec. 322) is seldom required by local inspectors but the wireman should be prepared to make the test if ever it should be required. Methods of testing insulation resistance are given in following sections.

NOTE.—THE "CODE" RULE GOVERNING INSULATION RESISTANCE is as follows:

"A completed installation shall have a resistance between conductors, and between all conductors and ground, not less than:"

| Current | Resistance Required |
|---|---|
| Up to 5 amperes | 4,000,000 ohms |
| Up to 10 amperes | 2,000,000 ohms |
| Up to 25 amperes | 800,000 ohms |
| Up to 50 amperes | 400,000 ohms |
| Up to 100 amperes | 200,000 ohms |
| Up to 200 amperes | 100,000 ohms |
| Up to 400 amperes | 50,000 ohms |
| Up to 800 amperes | 25,000 ohms |
| Up to 1,600 amperes | 12,500 ohms |

"The above values shall be determined with all cutouts and safety devices in place. If lamp sockets, receptacles, fixtures and other appliances are also connected, the minimum resistance required shall be one-half that specified in the table."

The current shown in the table is that which is required by the installation; it may be taken as equal to the capacity of the main cutout. Note that, in the above table, the product of the *current* and the *required resistance* always equals "20,000,000."

**322. To Measure The Insulation Resistance Of A Conduit-Wiring Installation,** either one of three methods may be employed: (1) *The "Megger" method* (Sec. 323). (2) *The voltmeter method* (Sec. 324). (3) *The Wheatstone-bridge* method, see note below. The "Megger" method gives the resistance

directly without any computations but involves the use of the "Megger," an instrument which is costly. The voltmeter method involves less computation (usually) than does the bridge method but a suitable voltmeter also is quite costly. A Wheatstone bridge may be purchased at small cost or may be readily improvised. Experience shows that the voltmeter and bridge methods are very much more difficult to execute than is the "Megger" method. In fact, many wiremen believe that the "Megger" method is the only reliable one.

NOTE.—THE WHEATSTONE BRIDGE AND ITS USE FOR MEASURING RESISTANCE are described in detail in the author's "American Electricians' Handbook," as are also methods of making improvised bridges. Inasmuch as a resistance test can be made in much less time by the voltmeter or by the "Megger" method, the bridge method is not recommended for insulation tests. Moreover, the bridge method requires more experience on the part of the person making the test and he is more likely to become confused with it than with either of the other methods.

**323. To Measure The Insulation Resistance Of A Conduit-Wiring Installation With A "Megger"** (Figs. 632 and 633)

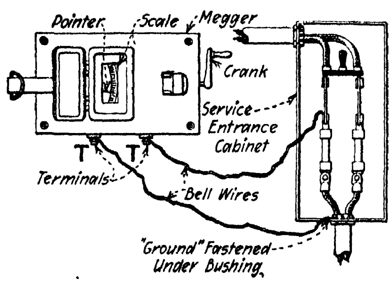



FIG. 632.—Connection diagram of the "Megger" method of finding insulation resistance between conductor and ground.

it is only necessary to connect wires from the terminals to the two conductors between which it is desired to measure the resistance and then to rotate the crank at about the proper speed (marked on box). The insulation resistance may then be read directly from the scale of the instrument. (It is to be understood that all energy-consuming devices—lamps and the like—are to be disconnected during this test and that all switches and cutouts are closed.) The insulation

resistance should first be measured between the conductors, thus: (1) *Between the two conductors of a two-wire system.* (2) *Between each two of the three conductors for a three-phase system.* (3) *Between the two outside wires and between the center—neutral—and each outside wire of a three-wire system.* The

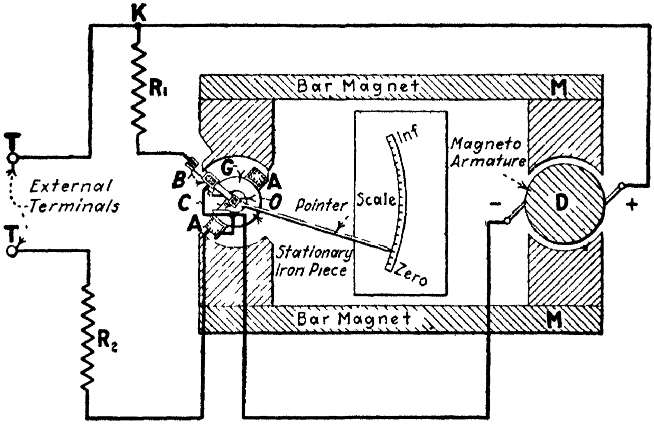



FIG. 633.—Diagram showing operating principle of the "Megger." Between the poles of the permanent magnets $M$ and $M$ there are mounted at one end the armature, $D$, of the hand-driven generator and at the other end three coils, $A$, $B$, and $C$, which are pivoted to rotate about an axis through $O$. When no electrical connection exists between the terminals $T$, the voltage produced by $D$ forces a current through $R_1$, $B$, and $C$, which are connected in series. This drives these coils to the point where minimum flux from the permanent magnets passes through them; that is, directly opposite the gap in the $C$-shaped iron piece $G$. In moving, the coils carry the pointer to the line marked "Infinity" on the scale.

When a suitably high resistance is connected between the terminals, $T$, the current from the generator divides at $K$, part passing through the external resistance and then through $R_2$ and the coil $A$. The current through the coil $A$ tends to rotate it in the opposite direction from that in which the current through $B$ and $C$ tends to rotate them. Since the coils $A$, $B$, and $C$ are all rigidly fastened, their position (and hence, that of the pointer) is determined by the relative currents through the two paths. If the terminals $T$ are short-circuited, the pointer will move to the zero of the scale. The resistances $R_1$ and $R_2$ function to limit the current through the coils and thus prevent damage.

insulation resistance from each conductor to ground should then be measured (the conduit itself, if already grounded, will serve as a conductor for this measurement). If the neutral is grounded, the resistance between an outer wire and the neutral will be the resistance to ground.

NOTE.—IF THE INSULATION RESISTANCE IS TOO LOW, that is, lower than is required by the "Code," it is very likely that some section of conductors has had its insulation damaged or that some other insulation (such as a slate switch-base or panel board) is defective. *The point of low resistance may be found* by elimination. Each of the feeders or mains is successively cut out of the circuit by opening the switch or cutout which controls it. The opening of one switch or cutout will probably relieve the low-resistance condition. The point of low resistance is then known to be in that portion of the wiring which was cut off by the switch or cutout. By following this same procedure for portions of this first-found portion and so on, the trouble can usually be traced to its actual location.

**324. The Voltmeter Method Of Measuring Insulation Resistance** (Figs. 634 and 635) is briefly this: A source of direct-current voltage, as high as possible, and a high-resistance voltmeter are required. A number of dry cells connected in series so as to give at least 7.5 volts is often a satisfactory

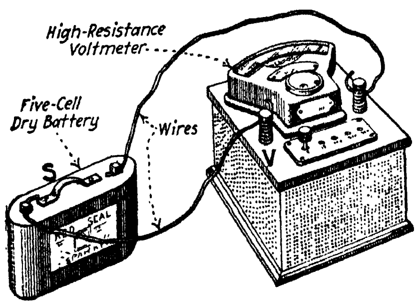



FIG. 634.—First step in measuring insulation resistance with a voltmeter.

source of voltage. The higher the voltage of the source, however, the more accurate will be the final result. The voltmeter, $V$, is first connected (Fig. 634) to read the voltage of the source, $S$. Call this reading of voltage $E$. The voltmeter is then connected (Fig. 635) in series with the voltage source and wiring system. (All switches and cutouts in the wiring system should be closed, but all energy-consuming devices—lamps and the like—should be disconnected from the system.) The voltmeter is now again read. This reading is called $E_1$. Now the resistance of the voltmeter may be determined (it is usually marked on the box). Call

the resistance of the voltmeter $R_v$. Then the resistance of the installation ($R$) may be computed by the formula:

$$R = R_v\left(\frac{E}{E_1} - 1\right) \quad \text{(ohms)} \tag{1}$$

Wherein the symbols represent values as designated above.

EXAMPLE.—In a building where the main cutouts have a rating of 100 amp., the readings of the voltmeter during an insulation test are as follows: Voltage of battery = 7.35 volts. Voltage reading when wires $A$ and $B$ (Fig. 635) are connected to conductors = 0.85 volts. Voltage when $A$ and $B$ are connected to one conductor and ground = 0.40 volts. The resistance of the voltmeter = 50,000 ohms. Does the insulation

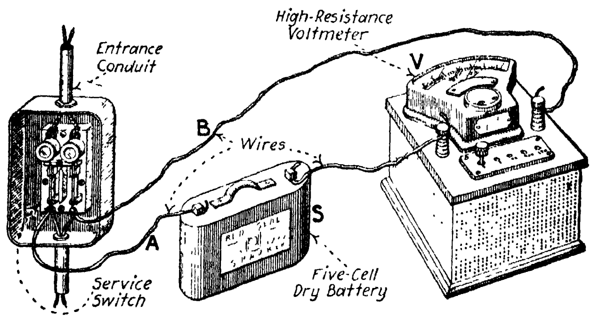



FIG. 635.—Second step in measuring the insulation resistance with a voltmeter.

comply with code requirements? SOLUTION.—For finding the insulation resistance between conductors, the values to be used in For. (1) are: $R_v$ = 50,000 ohms. $E$ = 7.35 volts. $E_1$ = 0.85 volts. Hence, by For. (1), the *resistance between conductors* = $R = R_v[(E/E_1) - 1]$ = 50,000 [(7.35 ÷ 0.85) − 1] = 50,000 × (8.65 − 1) = 50,000 × 7.65 = 382,500 *ohms*. Likewise, for finding the resistance between one conductor and ground, $E_1$ = 0.40 volts. Hence, by For. (1), the *resistance from conductor to ground* = $R = R_v[(E/E_1) - 1]$ = 50,000[(7.35 ÷ 0.40) − 1] = 868,750 *ohms*. Now, by code rule 507 (note under Sec. 321), the minimum allowable resistance for an installation requiring 100 amp. is 200,000 *ohms*. Hence, the insulation resistance of the installation of this example is ample to satisfy code requirements.

## QUESTIONS ON DIVISION 10

1. When, in the course of a wiring job, should the system be tested?
2. What good is accomplished by making tests of a wiring installation? (State the three conditions which are checked by the tests.)
3. In practice, what is usually done about tests for continuity and insulation?
4. Name the order in which tests for continuity and insulation should be made.
5. Explain, and draw a sketch to illustrate, a method of testing the electrical continuity of the conduit in a conduit-wiring installation.

**6.** How may piping within a building be used to simplify the testing of conduit system continuity?

**7.** Explain the procedure of finding and repair of a discontinuity in the conduit of a wiring system.

**8.** Explain in detail the method of testing wiring installations for short-circuits.

**9.** Draw a sketch to show how batteries should be connected to a three-wire system in testing for short-circuits.

**10.** Explain in detail the method of finding the point at which a short-circuit exists.

**11.** How may a wiring installation be tested for continuity of conductors and proper connections? Explain fully.

**12.** What is the purpose of the "Code" requirement for insulation resistance of wiring installations?

**13.** What are the three methods by which the resistance of the insulation of the conductors may be measured? What are their relative advantages and disadvantages?

**14.** Draw a sketch to show the principle of operation of a "Megger" and describe how the instrument functions.

**15.** How would you measure insulation resistance with a "Megger?" Explain fully.

**16.** If the insulation resistance is found to be too low, how may the weak point be located?

**17.** What are usually the weak points of the insulation of a wiring system?

**18.** Explain, with sketches, the method of finding insulation resistance by the voltmeter method.

## DIVISION 11

## CONDUITS FOR TELEPHONE CIRCUITS

**325. The Places Where Conduits Are Used For Telephone Circuits** are, in general, the following: (1) *Underground entrance wires* (Sec. 328). (2) *For carrying cables throughout apartment buildings, hotels, and office buildings,* especially in cases where the cables are small and in buildings of less than 12 stories (Sec. 327). (3) *For distributing twisted pairs from cable terminals,* especially in hotels, apartment buildings, and sometimes in office buildings (Sec. 327). (4) *For protecting or for concealing portions of circuits,* especially in residences and office buildings (Sec. 327).

NOTE.—CONDUITS SHOULD NOT, IN GENERAL, BE USED FOR SUCH TELEPHONE WIRING AS IS NOT LIKELY TO BE PERMANENT. That is, in office and loft buildings, the wiring which leads to the telephone instruments and which therefore depends on the desires of the tenant, should not, preferably, be placed in conduit. Some more flexible means of wiring should be employed so that the locations of telephones may readily be changed as when a new tenant takes possession. It is advisable, in such buildings, to run the wires in molding wherever feasible (see also Sec. 327).

**326. The Local Telephone Company Should Always Be Consulted** prior to the laying out or installation of *any* conduits for telephone circuits. In the following sections suggestions are given which will, ordinarily, apply generally. But your local company may have certain special requirements which must be satisfied; these must be ascertained. Furthermore, the local company may have available data or plans which relate to installations similar to that which you contemplate. Consideration of these may save you considerable effort and cost. For any project in which there will be more than a few telephones, the architect should always consult the local telephone company before proceeding with the plans. This should be done to insure that suitable cable shafts,

cabinet recesses, wire mouldings and the like will be provided by him in the contemplated building.

**327. The General Method Of Distribution That Is Employed In Wiring Buildings For Telephone Service** (Fig. 636) varies, as explained below, with the size and type of building that is to be served. In all cases, however, each direct-line telephone must be connected with the telephone exchange by a pair of wires. Each private branch switchboard must be connected with the exchange by one pair or a number of pairs (called *trunk lines*) and, usually besides those, by a pair of

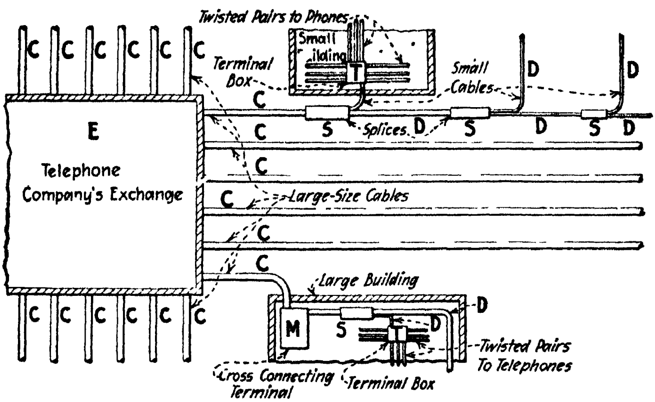



FIG. 636.—Diagram showing general scheme of distributing telephone service.

bell-ringing wires. The wires are carried from the exchanges ($E$, Fig. 636) in lead-sheathed *cables*, $C$, containing many pairs of small-size wires. The largest cables carry 1,212 pairs of wire. For distribution, the wires are carried as far as possible in the large cables, $C$, and are then spliced progressively to the wires of smaller and smaller cables $D$, $D$, etc. The smallest cables (which are used ordinarily only inside of buildings) contain but 6 pairs. Near the location of the telephones which are to be served, the cable is ended in a *cable terminal* or *terminal box*, $T$, from which the pairs of wire are carried to the telephones as *twisted pairs.* The terminal box serves merely as a junction box. The differences in the wiring of buildings of different types are about as follows:

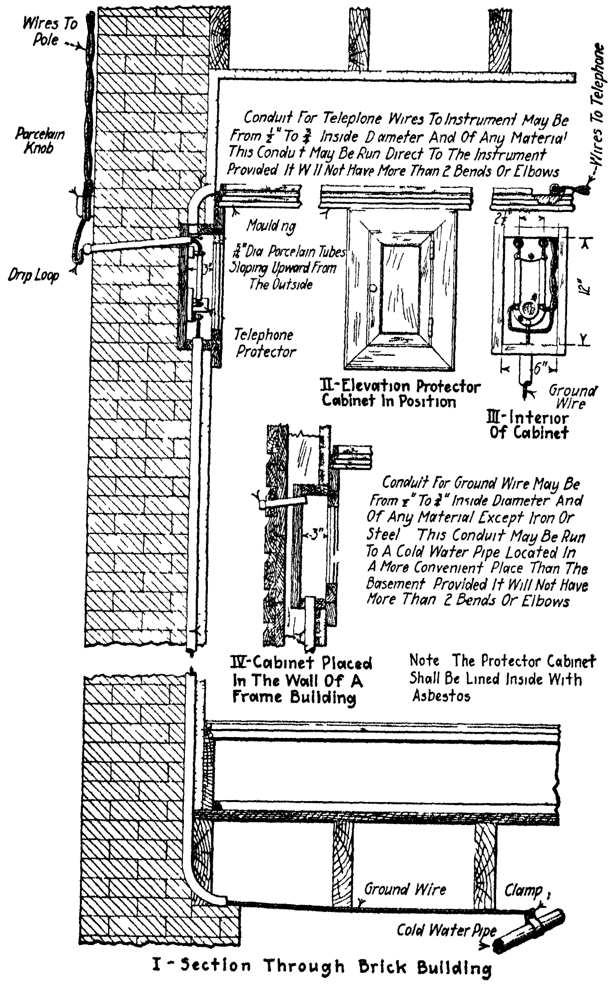



**Fig. 637.—Showing telephone wiring in a residence where conduit is used.**

THE TELEPHONE WIRING IN RESIDENCES, since residences usually contain but one telephone, consists of only one twisted pair. The cable terminal from which the twisted pair runs is located on a nearby pole (if the telephone cables in the neighborhood are run overhead) or in a manhole (if the cables are underground). The owner may, if he desires, arrange for an underground entrance of the wires (Sec. 328) and he may provide a cabinet (Fig. 637) for the telephone protector (which protects against excessive currents and lightning). He may further provide conduit for the wires to the instrument and for the ground wire (Fig. 637).

THE TELEPHONE WIRING IN APARTMENT BUILDINGS WHICH HAVE FEW FLOORS AND WHERE EACH APARTMENT HAS CONSIDERABLE FLOOR AREA (Fig. 638) is generally arranged as follows: A cable of sufficient

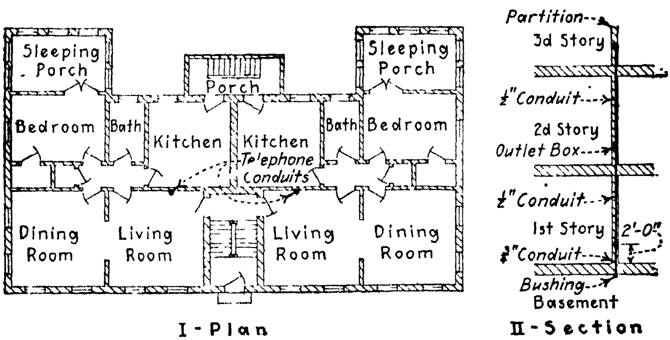



FIG. 638.—Plan of an apartment building and section showing method of placing conduits for telephone service.

capacity to serve the entire building enters a cable terminal in the basement. From the cable terminal twisted pairs are run to several points where riser conduits are placed so that each conduit serves a tier of apartments. Outlet boxes on the conduit risers serve to hold the boxes for desk telephones.

THE TELEPHONE WIRING IN HOTELS AND APARTMENT BUILDINGS, WHICH HAVE MANY FLOORS AND WHERE EACH APARTMENT HAS LITTLE FLOOR AREA, consists of one or more cable terminals on each floor from which conduit is run to the different apartments on that floor. The cable may be carried to the terminal boxes through conduit (similar to Fig. 639) or by means of a shaft in the building (as in Fig. 641). From the terminal boxes, a separate ½-in. conduit may be run to each telephone location, or the twisted pair wires for several telephones may be run through one conduit. A ¾-in. conduit should not be used for more than 4 *twisted pairs*, however, nor a ½-in. conduit for more than 2 twisted pairs.

THE TELEPHONE WIRING IN OFFICE BUILDINGS may be of the same nature as described above for hotels, as shown in Figs. 639 and 640, but

more often office buildings have a more "flexible" wiring arrangement. Inasmuch as the telephone arrangement in office buildings is subject to the demands of the tenants, such buildings are wired so that changes may be made with as little expense as possible. To this end, *cross-connecting terminals* (sometimes called *main frames;* see *M*, Fig. 636

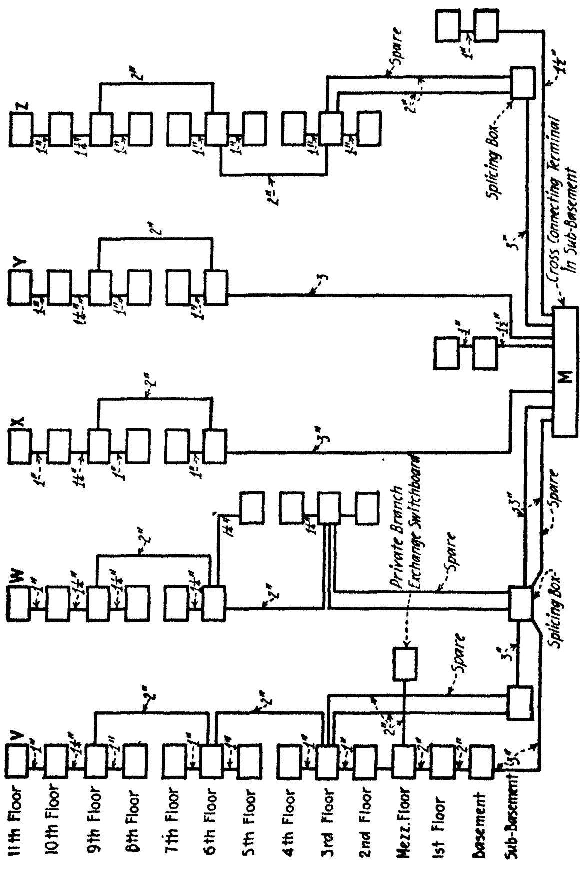



FIG. 639.—Conduit riser diagram of telephone conduits for a 11-story office building. See Fig. 640 for typical floor plan.

and Fig. 639) are generally placed in the basements to permit connecting together telephones on different floors and for other "flexibility" reasons. Furthermore, the twisted pairs from the cable terminals are generally run in *wire molding* (Figs. 641 and 642) rather than in conduit, so that changes in telephone locations can more readily be made. Further details of telephone wiring in office buildings, showing uses of conduit, are illustrated in Figs. 643, 644, 645, 646, and 647.

**328. Underground Entrance Conduits For Telephone Service** (Figs. 648 and 649) must, usually, be installed at the owner's expense whenever it is desired to conceal the entrance of circuits which emanate from overhead pole lines. The telephone companies will not install their wires in entrance conduits, however, unless the conduits comply with certain requirements: (1) *The size of the conduit* is usually 1½-in.

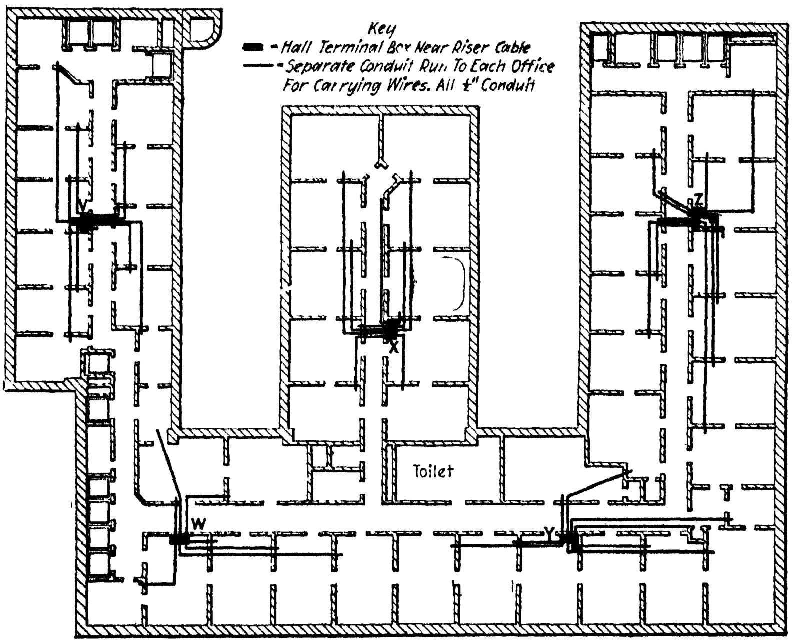



FIG. 640.—Typical floor plan of 11-story office building showing conduits for telephone circuits. See Fig. 639 for corresponding riser diagram.

for residences, 2-in. or larger for apartments, hotels, and office buildings. The minimum size for any given installation will be designated by the telephone company. (2) *The conduit must be laid as straight as possible;* it shall have no pockets which will collect and hold water and shall have no more than two bends. The bends shall have a radius of not less than 30 in. No reverse bends are permitted. (3) *All joints must be watertight.* (4) *The conduit must be at least* 30 *in. below the ground surface.* (5) *Drainage must be provided for.* The

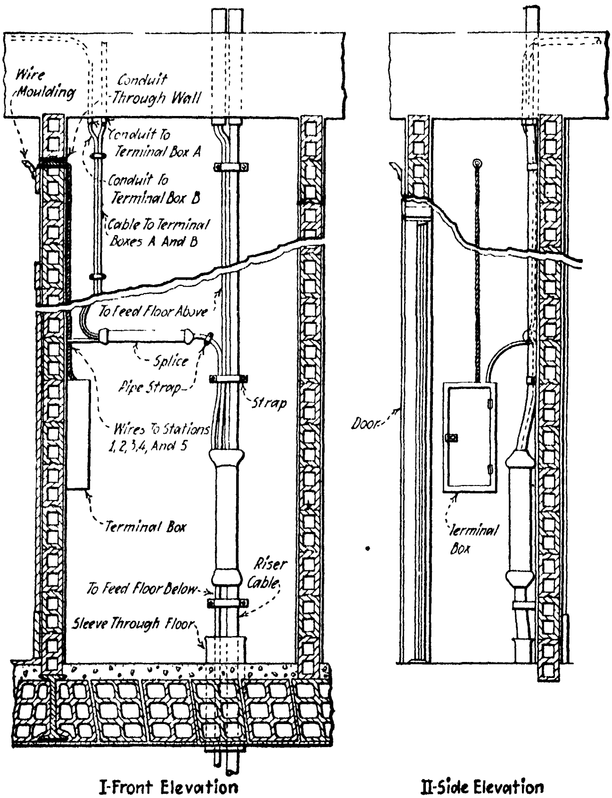



FIG. 641.—Sections through the cable shaft of an office building showing methods of distributing cables to terminal box.

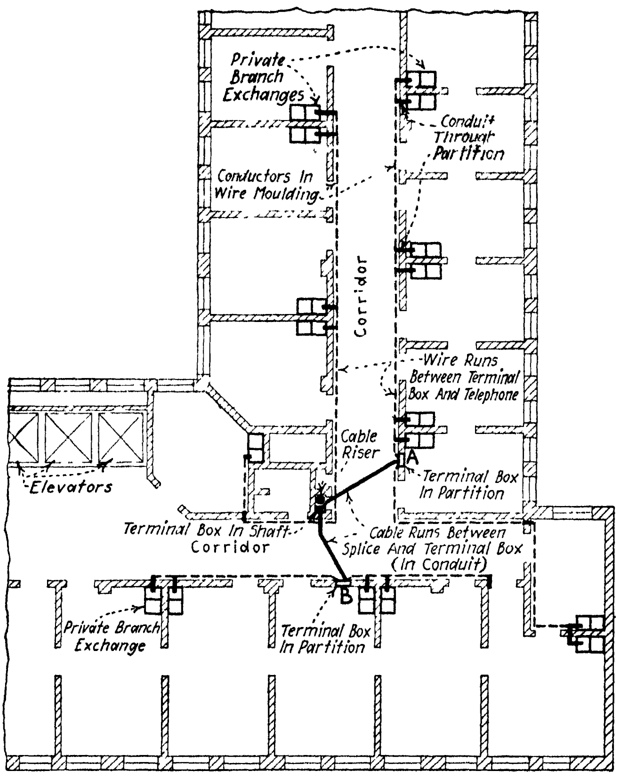



FIG. 642.—Partial floor plan of office building showing arrangement of telephone wiring (this is the same building as is shown in Fig. 641).

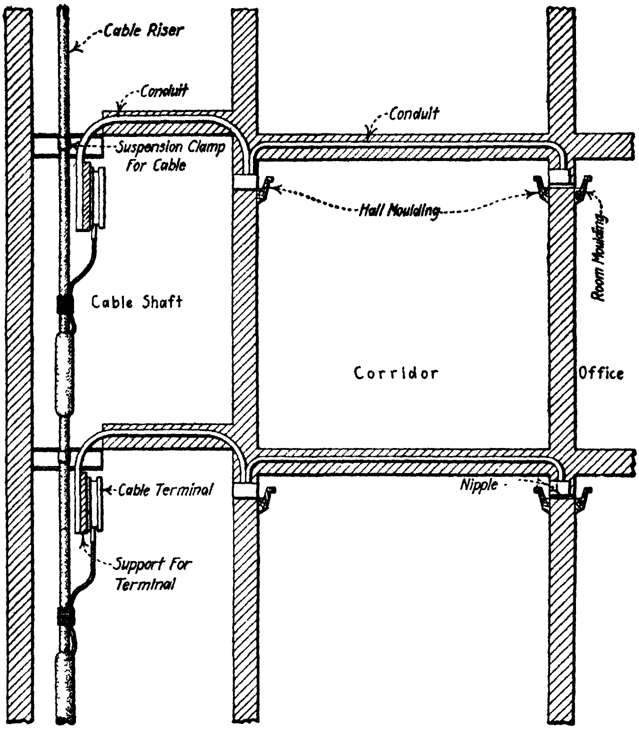



FIG. 643.—Section through cable shaft, corridor, and offices of an office building showing conduit-wiring details.

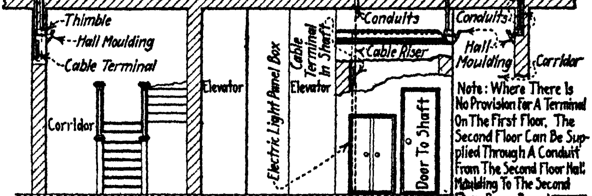



FIG. 644.—Section through an offce-building showing telephone wiring in conduit.

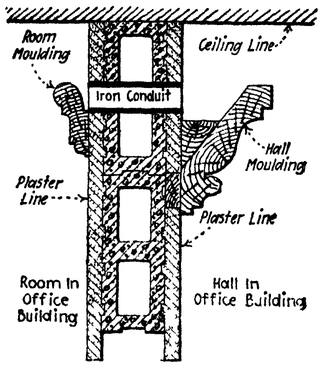



FIG. 645.—Conduit connection between wooden mouldings in hall and in rooms of an office building.

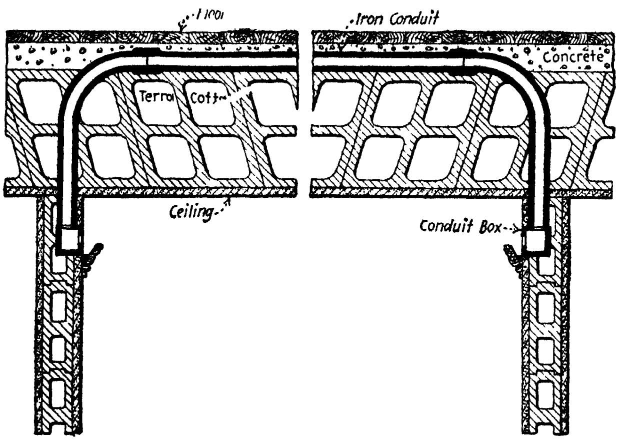



FIG. 646.—Concealed conduit connection between wooden wiring moldings on opposite sides of an office-building hall.

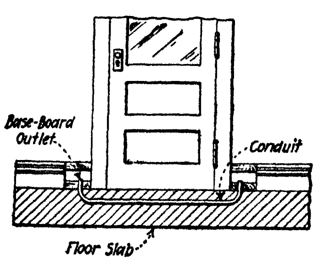



FIG. 647.—Baseboard molding connected around a door with concealed conduit.

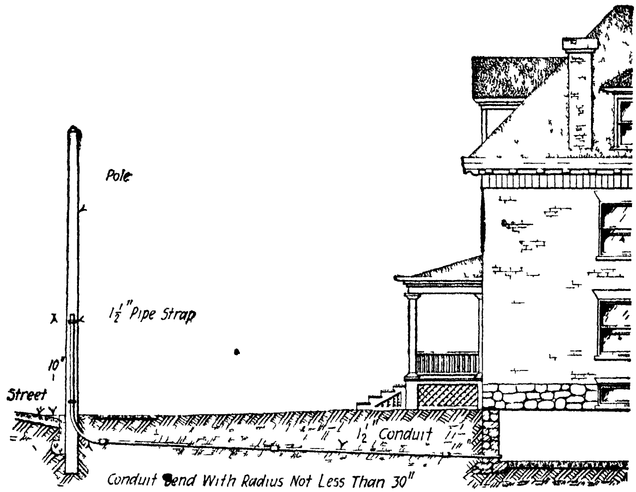



FIG. 648.—Run of private underground entrance conduit from a pole to the basement of a residence. Drainage is toward the basement (preferable direction).

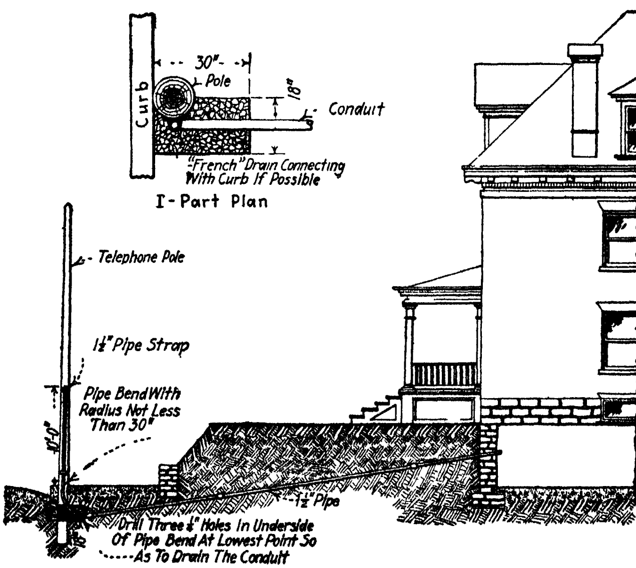



FIG. 649.—Run of private underground entrance conduit from a pole to the basement of a residence. Drainage is toward the pole due to high location of building. A "French" drain is simply a mat of stones, which are about 2-in. in diameter intended to provide space between the stones for drainage.

conduit should be arranged to drain either toward (Fig. 648) or away from (Fig. 649) the building served.

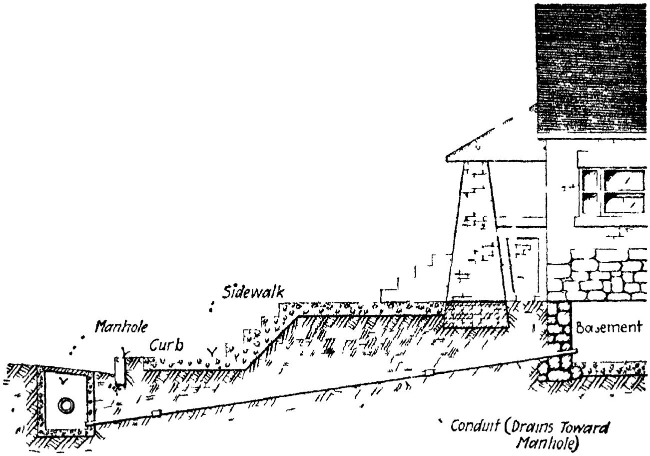



FIG. 650.—Private underground entrance conduit from manhole to residence. Drainage is toward manhole (preferable direction).

NOTE.—UNDERGROUND ENTRANCE CONDUIT FOR TELEPHONE SERVICE MAY EXTEND FROM A POLE OR FROM A MANHOLE (Fig. 650), depending on the method of distribution and the location of the telephone company's wires in the neighborhood (whether overhead or underground). Note from Fig. 650 that where a building is served from a manhole, the preferable direction of drainage is toward the manhole, whereas for buildings served from poles, the preferable method of drainage is toward the building (Fig. 648). Always consult your local telephone company before making any definite plans. It is not ordinarily feasible to serve a single telephone or a few telephones from a manhole, unless it so happens that the telephone company already has a distribution box installed in the manhole or desires to install a distribution box in it.

### QUESTIONS ON DIVISION 11

1. State briefly the five places where conduits are used for telephone circuits
2. What is the general rule governing the use of conduits for telephone wiring? Explain fully.
3. Draw a diagram to illustrate the general method of distribution which is employed for telephone service
4. Define: *Trunk line Cable. Cable terminal*
5. What is the maximum and minimum number of pairs of wires in telephone cables?
6. What is the usual location of the cable terminal in residential telephone wiring?
7. For what purposes may conduit be used for telephone circuits in residences?
8. Explain and draw a sketch to show the general method of installing the telephone wiring in an apartment building which has few floors and where each apartment has considerable floor area.

**9.** Describe the method of wiring hotels and similar apartment buildings for telephone service.

**10.** How many twisted pairs may be run in a ¾-in. conduit? In a ½-in. conduit?

**11.** In what manner does the telephone wiring in office buildings differ from that in hotels?

**12.** What is the purpose of a cross-connecting terminal?

**13.** What is the purpose of using conduit for the entrance of telephone wires? Who ordinarily pays for installing this conduit?

**14.** What are the requirements of conduit for underground entrance of telephone service?

**15.** What is the preferable direction of drainage for an underground conduit connecting a building to a pole? To a manhole?

**16.** Draw a sketch and describe the method of draining an underground entrance conduit which slopes downward from a building toward a pole.

# DIVISION 12

## CONDUIT WIRING IN DAMP AND OTHERWISE HAZARDOUS PLACES

**329. Conduit Wiring In Places Subjected To Moisture Or Corrosive Vapors** (packing houses, glue houses, cold storage rooms, etc.) should be installed with exceptional care to meet the severe conditions encountered. If ordinary conduit is installed in such places in accordance with the usual methods, it may corrode so rapidly that in a relatively short time only a shell is left hanging on the wires. Special precautions must be taken to reduce the corrosive action of the vapors. The precautions to be taken and the methods of installing conduit wiring which should be generally employed in the various hazardous places are discussed in the succeeding sections. They have proved satisfactory in some installations but may not, necessarily, prove so in every individual case. No method has, apparently, been found, as yet, which is entirely satisfactory for the most severe conditions.

NOTE.—THE METHOD OF WIRING TO BE EMPLOYED in any place, should be one that will overcome, as effectively as possible, and with the least expense, the peculiar conditions there encountered. Thus, prior to the installation of conduit in any hazardous place, the detrimental conditions there existing and their effects on the various wiring materials should be determined. After the conditions are known, an effort should be made to devise a satisfactory method of wiring by following the principles and suggestions given in this division.

NOTE.—THE MATERIAL IN THIS DIVISION IS BASED LARGELY ON ARTICLES by Frank F. Sengstock and F. G. Waldenfels which have appeared in various electrical periodicals. See the books "Electrical Hazards and Their Prevention In Various Occupancies," published by *Fire Protection*, Indianapolis, and "Electrical Wiring Manual," published by Modern Publishing Company, New York, 1920, both by Sengstock. See also material by Waldenfels in "Handbook of Electrical Methods," McGraw-Hill Book Co., New York, 1913.

**330. Conduit Wiring, Properly Installed, Has Been Found Preferable To Open Wiring In Places Where Moisture And Corrosive Vapors Are Present.**—Up to the present time, ordinary conduit has been charged with two deficiencies, *corrosion* and *condensation.* These deficiencies still exist and steel conduit installed in the usual manner will, under severe conditions, readily corrode away. But conduit will, if it is properly installed and is protected insofar as is feasible from the corrosive vapors, last as long as, if not longer than any special form of open wiring. The conduit method of wiring, when properly installed, has several advantages over the open wiring method: (1) *It protects the conductors from mechanical injury.* (2) *It requires less space and less head room than the special open-wiring methods.* (3) *It costs considerably less and requires less maintenance than the special forms of open wiring which are generally employed.* In *glue houses,* where conditions are ordinarily severe, conduit has, usually, corroded rapidly but even in these places it has often given good service.

NOTE.—THE AMOUNT OF PRECAUTION TAKEN IN INSTALLING THE CONDUIT SHOULD VARY WITH THE SEVERITY OF THE CONDITIONS which exist at the place of installation. In places where only moisture was encountered, ordinary conduit has given fairly good results; but some moist locations are more severe on conduit than others. In other places steam, ammonia, sulphur, and acideous vapors have readily corroded the conduit. It is usually better to take too much precaution than not to take enough. The more precaution taken in installing the conduit, the less will be the trouble afterwards experienced in maintaining the installation.

**331. Hot-Dipped Galvanized Conduit Resists The Corrosive Action of** moist and acideous vapors (Sec. 19) better than any other steel conduit. It serves very well in most places. However, *hot-dipped galvanized pipe* has persisted in places where the conduit has failed. If the burrs are properly removed from the interior surface of the pipe, it is to be commended for severe packing-house installations. Sherardized and electrogalvanized conduits are satisfactory under less severe conditions. Enameled conduit is the least desirable of all the conduits; it should not, unless carefully handled, be used when the atmosphere contains corrosive

vapors such as exist in the tank rooms, glue houses, and fertilizer rooms of packing plants.

Note.—None Of The Conduits Are Treated Uniformly during their process of manufacture. One length of conduit of the same grade will corrode more rapidly than another length. This non-uniformity causes a small part of an installation to corrode more rapidly than the main portion. This small part can usually be repaired at a small cost.

Note.—The Rigid Aluminum Conduit (Sec. 22), now made, would seem to be a very satisfactory conduit for installations subjected to moisture or corrosive vapors. The aluminum, which is itself somewhat non-corrosive, is protected by the formation on its surface of a thin film of aluminum oxide, a very inert substance. This conduit is relatively new and has not, up to this time, been very widely used.

**332. Painting Ordinary Conduit Enables It To Effectively Withstand Corrosion Much More.**—Ordinary conduit when painted, after installation, with a good waterproof paint, has been found to "stand up" satisfactorily under severe conditions where without painting it would last only a few months. Best results have been obtained with a silicate graphite paint, but insulating paint or asphaltum has also given good results, especially where the conduit was exposed in packing houses to the steam from carcasses in process. Aluminum paint has likewise been found very satisfactory. After the initial installation and painting of the conduit system, it should be repainted at intervals of about every 6 or 8 months.

Note.—Another Method Of Lengthening The Life Of A Conduit Installation which is subjected to severe conditions is to: (1) *Paint the conduit with an insulating paint,* (2) *serve it with an enclosing winding of a good linen tape, and* (3) *then add another coat of insulating paint.* This method is expensive, but in extremely corrosive places it may be desirable. Such a protective coating will increase the life of the conduit by from one to five times.

Note.—Test To Determine The Life Of Conduit And The Effects Of Protective Coatings On It were made by F. F. Sengstock (*Fire Protection*, 1918). Sengstock subjected samples of 21 different makes of conduit to the moisture and corrosive vapors of a glue-house cook room in a packing plant. All samples were subjected to exactly the same conditions. At the end of the 13-month test period all samples showed deterioration. The approximate corrosion varied from 2 to 60 per cent. Also the test showed that, in certain instances, on conduit of certain makes, painting promoted instead of retarded corrosion. On conduit of

other makes painting retarded corrosion. Furthermore the test proved that a conduit protected by, (1) a coat of paint, (2) a serving of tape, and (3) another coat of paint would have a life from 1 to 5 times greater than that of an unprotected conduit. No perfect length of conduit, which was thus protected with a painted-taped serving showed corrosion under the tape. Galvanized wrought-iron pipe lasted longer than any other of the conduits.

**333. Great Care Should Be Exercised When Installing Conduit In Damp And Corrosive Places.**—The conduit should be carefully handled so that it will not be marred or scratched more than is unavoidable. Wrenches and other tools which scratch the protective coating should be carefully used. When the conduit will be subjected to severe conditions, it should be repainted at the points along the run where the protective coating was accidentally removed. The exposed threads at all joints and conduit fittings also should be carefully painted. Only cast-iron conduit fittings should be employed. It is well to provide a gasket between the cover and the body. Before the conduit is screwed into conduit fittings and couplings, the threads on the conduit should be coated with white lead.

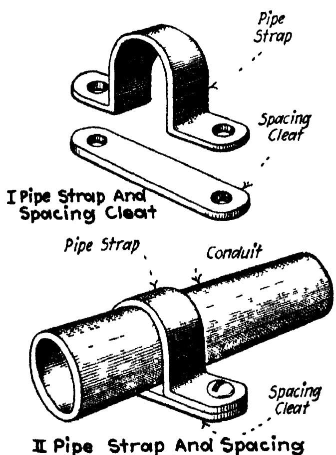



Fig. 651.—Spacing cleat employed to keep conduit from touching the surface on which it is installed.

Note.—Much Future Maintenance Trouble Can Often Be Avoided If The Conduit Runs Are Carefully Planned before they are placed. Frequently, one part of a room is less injurious to conduit than another part. If in such cases, by shifting the location of the conduit run a few feet it may be so placed that it will have a much longer life.

Note.—Air Spaces Should Be Provided on all sides of the conduit so that the moisture which may collect will evaporate readily. Supports should be so installed that any moisture which may collect on the conduit will drain off easily and not be "pocketed" at the support. Flat *pipe straps* are preferable to the ribbed straps, which may fill with water and cause corrosion. Spacing cleats (Fig. 651) should preferably be inserted under each pipe strap to hold the conduit away from the supporting surface.

NOTE.—MARINE-TYPE FITTINGS ARE JUSTIFIED FOR IMPORTANT CONDUIT INSTALLATIONS IN DAMP PLACES. Such fittings are regularly manufactured by a number of concerns (Russell & Stoll Co., New York City, for example) for use on shipboard. These fittings are either of cast iron or brass. All are provided with gasketed covers and water-tight connections. All switch fittings are specially constructed to prevent the entrance of moisture. These marine fittings are considerably more expensive than the ordinary equivalent fittings but under severe conditions, an investment in them will be found a paying one.

**334. The Condensation Of Moisture In Conduit Systems** has given considerable trouble. The condensation occurs principally in runs which are subjected to vapors and which also pass through high-temperature and low-temperature zones. In such runs warm, moist air enters the conduit at a warm part of the run. This warm moist air passes to a cooler location in the conduit run. There some of its moisture is condensed into water. Such condensation within the conduit tends to corrode it from the inside. In addition, the condensation, as it accumulates, is likely to break down the insulation on the conductors in the conduit, and usually causes short-circuits. Fires and burn-outs may result.

**335. The Effects Of Condensation In A Conduit Run Can Be Eliminated** in one of two ways: (1) *By properly draining each end of the conduit* (Figs. 652, 653, and 654). (2) *By*

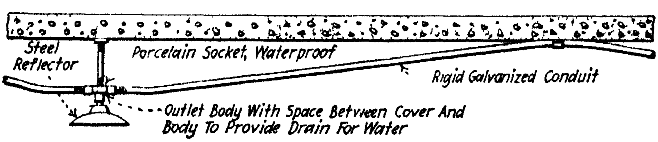



FIG. 652.—Provision for draining conduit through outlet body. Washers are placed on the screws between the body cover and the body to provide space for drainage. Leather washers have been used successfully. Brass washers are not satisfactory as they promote electrolytic action.

*plugging up or interrupting the air passages* (Figs. 655 and 656) *in the conduit at locations where the temperature changes abruptly.* The draining of the conduit is easily accomplished. It may be drained through each outlet fitting (Fig. 652), or through conduit fittings located between the outlet fittings (Fig. 653). The former method is well adapted for installations wherein the lamp receptacles are held on vertical con-

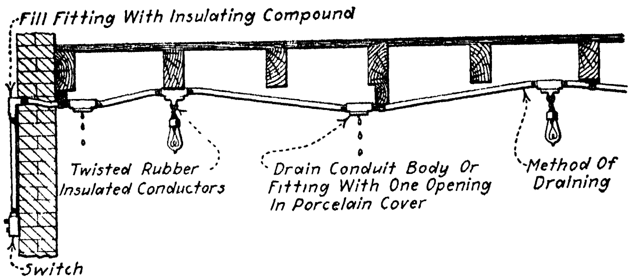



FIG. 653.—Provision for draining conduit with a conduit fitting between every two outlet bodies. A porcelain cover provided with one hole is used on the "drain conduit fitting."

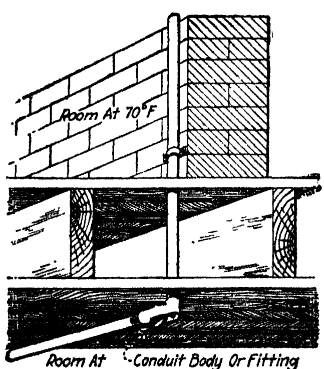



FIG. 654.—Provision for draining a vertical conduit run. This run extends from a room at a temperature of 40° F. to one at 70° F.

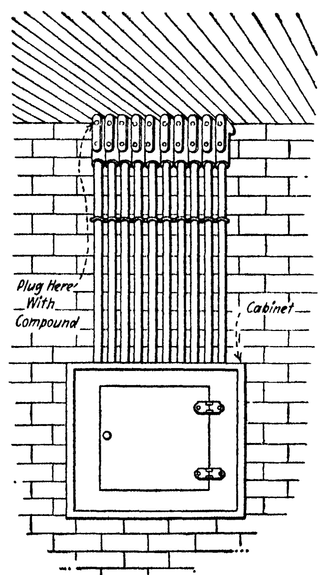



FIG. 655.—Sealing conduits with an insulating compound at the place where they enter a room which is at a lower temperature. This method minimizes condensation.

duit nipples. Where long insulated-wire drops are provided, the latter method is desirable because, with it, there is no danger, as there is with the former, of the condensation falling on the drop conductors. The practice of draining the conduit by drilling a hole in the lower end of each length is not recommended. Such a hole will soon be closed by corrosion. Thereby, its usefulness will be ended and at the same time the conduit will be damaged. Vertical runs can be drained as in Fig. 654. Plugging the conduit with *insulating compound* at an outlet body located where the different temperatures are encountered (Figs. 655 and 656) is also effective. The sealing must, however, be carefully done because the presence of even the smallest air passage will permit condensation. While both methods are effective the draining method is usually preferred.

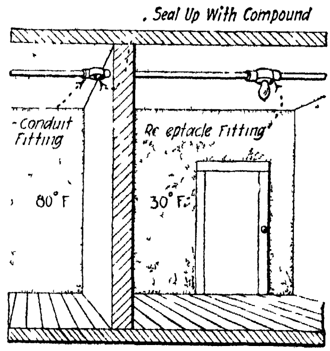



FIG. 656.—Sealing conduit with an insulating compound when the run is horizontal.

NOTE.—IN COLD-STORAGE WAREHOUSES AND OTHER SIMILAR PLACES MERELY SEALING THE CONDUIT AT THE ROOM ENTRANCE IS NOT VERY EFFECTIVE. In any situation where the temperature varies considerably, as in the cold-storage warehouses, condensation will always occur in the conduit (due to the temperature change in the room) even though the conduit entrance to the room is sealed. In such places, when the closed (sealing) method is to be used *each* section of conduit must be carefully sealed. Such sealing always requires considerable care and even then it is likely to be imperfect because crushed fittings or loose threads may permit moist air to enter. If the air enters condensation may occur. The open (drained) method is preferred in all such places, but the conduit entering the room should also be sealed.

NOTE.—WHEN WIRING MOTORS IN CONDUIT IN DAMP PLACES, it is undesirable to route the conduit downward from the control box (*S*, Fig. 657) and then horizontally across the floor to the motor. Water will collect in the horzontal run unless it is drained and it is very difficult to drain properly. A much better method is that of Fig. 658. In this, the conluit, *B*, from the control box is first carried vertically upward to the ceiling. Then the run is continued across the ceiling to a point directly over the motor terminals. This ceiling run is pitched so that it

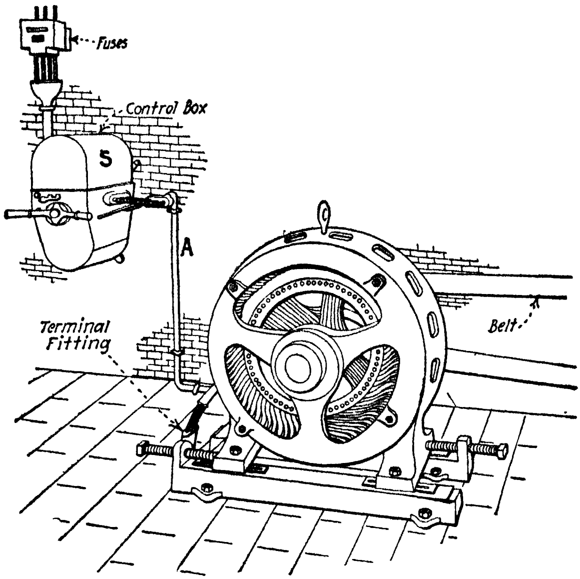



Fig. 657.—Conduit installation for a motor as ordinarily made.

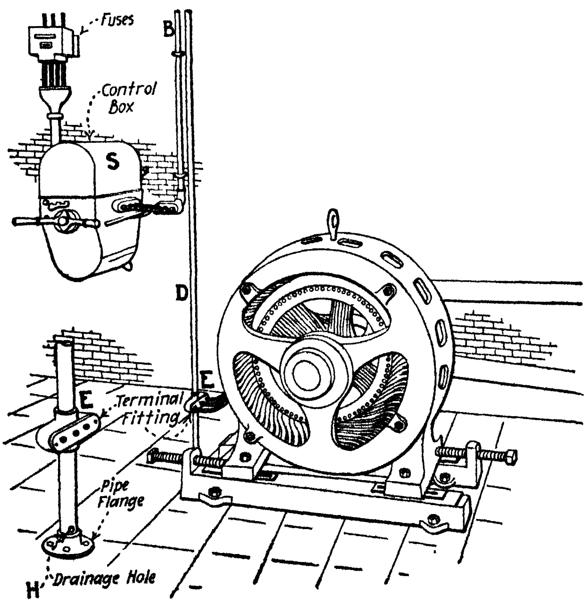



**Fig. 658.—Conduit installation for a motor as it should be made in damp places.**

will drain. From the end of the ceiling run, a conduit, *D*, is carried vertically downward past the motor terminals. At a location directly opposite the motor terminals a terminal fitting, *E*, is inserted in the vertical run. A weep hole, *H*, should be drilled at the extreme lower end of the vertical run. This arrangement provides adequate drainage.

NOTE.—IN PLACES WHERE VAPORS, WHICH ARE VERY INJURIOUS TO THE INSULATION OF THE CONDUCTORS, ARE PRESENT the closed or sealed method may be preferable. This method will protect the insulation from the vapors while the open method will not.

**336. A List Of "Hazardous" Places Where Conduit Has Been Installed,** with comments as to the life and condition of the conduit follows (F. G. Waldenfels, in "Handbook of Electrical Methods"):

COLD-STORAGE WAREHOUSE.—Enameled conduit was installed 7 years ago as an experiment. Some of the conduit was run continuously from the cabinet in the passageway, where the temperature was about 68° F., to the cold-storage rooms where the temperature 10 deg. below zero. Some of the conduit was plugged at the partition in the passageway. All the conduit is now in good condition; in fact it all looks like new, and there is no condensation or corrosion in either case. This is probably due to the extremely low temperature.

COOLER OR HANGING ROOMS.—This is a room where the cattle hang and steam (cool) after being killed. Sherardized conduit is plugged at the partitions as shown in Fig. 656. After 3 years no condensation or corrosion is visible.

TANK ROOMS.—In these places the offal of the plant is boiled into fertilizer by a process in which sulphur and ammonia are used. The resulting vapor attacks metals. The building is constructed of reinforced concrete. Exposed sherardized and galvanized conduit was used for wiring and was installed 2½ years ago. Ninety per cent. (approximately) of both types turned white and are giving good service; the other 10 per cent. of both types of conduit was practically eaten away. This installation was not drained or plugged. A long life is assured for the 90 per cent. of the conduit on which the white coating formed. The remaining 10 per cent. was replaced with little cost.

GLUE HOUSE.—Thus far no kind of conduit, except some hot-galvanized water pipe, used as an experiment, has withstood the attacks of fumes in this place. Every available kind of conduit was tried, but all corroded rapidly. A section of hot-galvanized water pipe has been in service 3 years, and since it has turned white it will probably last many more years. This experiment demonstrated that hot-galvanized pipe is what must be installed to withstand successfully the severest conditions encountered in packing-house work.

BORAX MILL.—About 3 years ago a room, in which borax liquid is allowed to steam and crystallize, was wired in enameled conduit. The

installation is still in excellent condition and no corrosion whatever is visible.

Canning Department.—A canning department was wired with enameled conduit and cast-iron boxes 7 years ago. Recent inspection revealed that the conduit was only slightly attacked over the boiling tanks. The rest was in excellent condition.

Pickling Department.—In this place salt water is continually condensed on the ceilings and walls. Enameled conduit and galvanized conduit have been installed for 15 months. They were drained as shown in Fig. 653. Both are in excellent condition. No grounds have occurred. In another instance lead-sheathed, flexible-steel armored conductors have been in use for over 30 months and were still in very good condition.

Fertilizer Rooms.—Several are wired in conduit but not in damp or wet places. Any first-grade conduit should give good satisfaction. Wet fertilizer attacks all conduits very readily.

Hair House.—Conduit, with cast-iron boxes, has given good results except in dyeing rooms or in damp places. With hot-galvanized conduit, properly drained, it should be feasible to wire every part of a hair house in conduit.

Oleo And Oil Houses.—Conduit gives excellent results wherever there is plenty of grease. Over the scrap kettles steam had caused some trouble, but if the proper conduit is employed and drained no trouble should ensue.

**337. The Conductors In Cold Storage Rooms And Other Damp Places** should be of a better grade than those employed in ordinary installation. Braided covering, regardless of the excellence of the rubber insulating compound which is used on the conductors, deteriorates rapidly in the presence of moisture or corrosive vapors. In properly drained conduit installations, double-braided single conductors coated with shellac by a dipping process have been found quite satisfactory. Twin conductors or conductors with a single braid, however, are not to be recommended for such service.

Note.—Where Excessive Condensation Is Present In The Conduit, Lead-Covered Rubber Insulated Wire Has Been Found Desirable. The lead-covered wire although it costs twice as much as the braided wire, will, in such places, be the more economical because of its much longer life. Lead-covered wires should also be used in rooms where corrosive vapors are present—such as fertilizer rooms, where ammonia vapor, which is detrimental to braided wire, is present.

Note.—Joints In The Conductors should be carefully made. Standard splices which are approved by the underwriters (see the author's "American Electricians' Handbook") are desirable. Each

joint, after being soldered, should be covered with an insulating compound as a protection against moisture. Rubber tape should then be applied to the whole joint, followed by several tight layers of friction tape. For a good job, the whole joint should be waterproofed with an insulating paint or with shellac.

**338. Wire Drops In Damp Or Corrosive Places** (Fig. 659) give considerable trouble. The wires of the drops become saturated with moisture. The insulation is deteriorated thereby and short circuits often result. Under such conditions, ordinary commercial wire will not give satisfactory service. Satisfactory results have been obtained by using a pair of stranded No. 14 rubber-covered, single-braided wires. The life of these wires may be lengthened by coating them with shellac or with an insulating paint. For severe conditions, best results are obtained with *packing-house cord.* Such a cord, which consists of twisted rubber-insulated conductors enclosed by a heavy rubber covering, and protected by a suitable jute reinforcement and a braid withstands moisture very well.

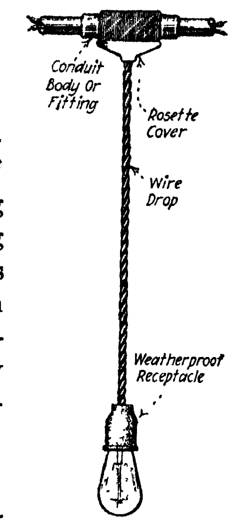



FIG. 659.—Wire drop from a conduit run.

NOTE.—SOLID CONDUCTORS are not recommended for drop cords. The drop cords are frequently bent back and forth. Such bending will readily break a solid conductor and may cause a short-circuit, or heating at the contact between the broken parts of the wires.

**339. Wire Drops Should Preferably Be Out Of Reach** of the workman. Where a workman can reach a drop cord, he frequently extinguishes the light by turning the lamp in the socket. This twists the joints on the drop wires until the wires become bare and contact with one another. Short-circuits are thus caused and flames may feed along the conductors and set fire to combustible material.

NOTE.—LAMPS ATTACHED DIRECTLY TO CONDUIT FITTING SOCKETS (Fig. 660) are to be preferred to wire drops. These lamps are safely out of reach and eliminate the hazard which is always present when wire drops are used. Vaporproof bodies and reflectors (Fig. 661) are also very satisfactory.

NOTE.—EXTENSION CORDS ARE ALWAYS A HAZARD in these hazardous places. They should be avoided wherever possible. When extension cords are necessary, only good packing-house cord should be employed. A wood or insulating handle should be attached to the lamp. The lamp should be protected by a galvanized-iron guard.

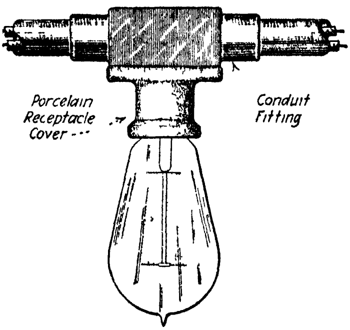



FIG. 660.—Lamp attached directly to conduit fitting socket.

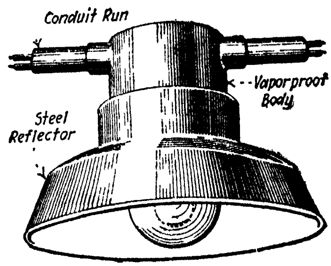



FIG. 661.—A vapor-proof body and reflector. (*Crouse-Hinds Co.*)

**340. The Desirable Socket For A "Hazardous" Installation** depends on the conditions encountered. In damp or wet places, brass shell sockets are not desirable. The paper insulation inside the shell becomes water-soaked and short-circuits result. In such places, only keyless weatherproof sockets

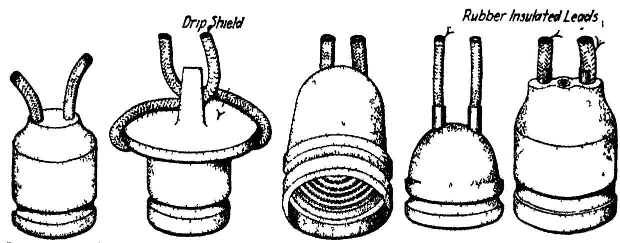



FIG. 662.—Some types of weatherproof sockets.

should be installed. The porcelain weatherproof sockets, however, are fragile and cannot stand rough usage. Many of them will be found broken after 6 months of service. They are best suited for high ceilings, where the sockets are not subjected to mechanical injury. The old-style porcelain

sockets which are sealed with a sulphur should not be employed. This compound expands, when subjected to moisture and temperature change, and thus cracks the socket. Hard-rubber molded or mica sockets (Fig. 662), are best and cheapest for use in wet places where the ceilings are reasonably high. They will not crack like porcelain sockets and can withstand extra hard usage. They are constructed even better than the vaporproof socket (Sec. 345) in that they have a solid body of composition supporting the shell.

Note.—Key Sockets Are Hazardous in damp or dusty places. Moisture enters the socket through the space around the key stem and short-circuits may occur.

Note.—Tape May Be Served Around The Top Of An Incandescent Lamp Where It Enters A Socket, to prevent the entrance of moisture, vapors or dust. In moist locations, the completed tape serving should be painted with an insulating or asphaltum paint. In dry locations painting is unnecessary. Each time a lamp is changed the old tape serving must be removed and a new one applied.

Note.—Brass Thompson-Houston (T-H)—Base Key Sockets, When Protected, have given better results in wet and steamy places than some weatherproof sockets. The T-H sockets were first painted with white lead, then taped with friction tape, and then painted again with white lead or asphaltum. The No. 14 stranded wires entering the ⅜-in. cap of the socket were first taped and then treated with compound to keep out the moisture. This construction formed a non-corrosive, unbreakable socket and still the lamp circuit could be opened and closed with the key of the socket.

**341. Switches And Fuses** should preferably be placed outside of moist or damp rooms. A rotary snap switch, located on the outside near the door with a pilot light over the door to indicate whether or not the lamps inside are burning, is a very desirable arrangement. When lamp-circuit switches must be located in the damp room, either a rotary or a push-button snap switch is a safe one to use. Small knife switches which are not externally operated are too dangerous in damp places, especially where foreign laborers are employed. The insulating paper lining under the metal shell of snap switches often gives trouble. This paper absorbs moisture, swells, and causes short-circuits between the inside screw terminals and the enclosing metal shell. Such troubles may be largely prevented by treating the metal cover with a coat of asphaltum

or lacquer. When push-button switches are used, a good rubber gasket should, preferably, be placed between the outer plate and the conduit fitting to assist in preventing moisture from entering the fitting.

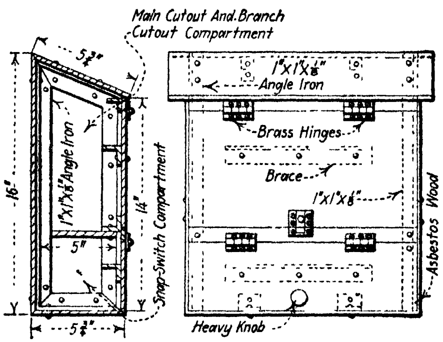
NOTE.—SNAP SWITCHES WHICH HAVE PORCELAIN SHELLS have not proven satisfactory in packing houses because they break so readily when subjected to rough usage. There is manufactured a snap switch for damp places which has a composition hard-rubber cap 1/8 in. thick that will withstand hard usage. Covers of this type that fit different switches can be obtained separately.

**342. When Knife Switches Are Employed,** they are placed in large cabinets. Several switches and cutouts, all mounted on the same backing, may be placed in one cabinet. The cabinets keep most of the moisture from the switches and reduce the corrosion. Some moisture is, however, always present in the cabinet. To protect the switches from this moisture, all the exposed metal parts should be kept well greased. Instead of greasing the parts, they may, all except the contacts, be well painted. A like protective coating should be applied to the terminals on the cutouts. A lamp may also be kept burning inside the cabinet to keep it dry. The lamp will, if the door is provided with a glass insert, serve as a guide for locating the cabinet in the dark.

NOTE.—AN ORDINARY KNIFE SWITCH HAS SEVERAL DEFECTS that cause overheating. A large switch that is frequently opened and closed will loosen at the hinges; the nuts will work loose, and release the spring washers. Very often the lugs or wires are not screwed down tight at the terminals. Frequently the threads are stripped on the terminal screws by pulling the nuts down too hard and the defect not remedied because it would require taking down the whole switch base. All these defects lead to overheating. Another trouble may occur with a cartridge-fused knife switch, in which the jaws of the switch are at the same height as the ferrule or knife-blade contact of the fuses. When the switch is opened and thrown against the fuses the switch handle and blades act as a lever, wedge against the fuses, and enlarge the clips. This causes the contacts to heat when in circuit because of the loose connection.

**343. Cabinets For Service In Damp Places** (Figs. 663 and 664) may be of sheet steel, asbestos wood or wood lined with asbestos wood. The wooden cabinets lined with asbestos

wood are, probably, preferable to the others. It is desirable to make them as waterproof as possible. The wood most used is ⅞-in. pine. The cabinets are generally about 6 in. deep. In wet places, the top is made slanting so that the




| Cutouts Main | Branch | Length Inside |
|---|---|---|
| 1 | 1 | 9.5" |
| 1 | 2 | 1'-1.5" |
| 1 | 3 | 1'-5.5" |
| 1 | 4 | 1'-9.5" |
| 1 | 5 | 2'-1.5" |
| 1 | 6 | 2'-5.5" |
| 1 | 7 | 2'-9.5" |
| 1 | 8 | 3'-1.5" |
| 1 | 9 | 3'-5.5" |
| 1 | 10 | 3'-9.5" |

FIG. 663.—Asbestos wood, steel-reinforced cabinet for protecting snap switches and fuses in damp places. (*F. G. Waldenfels.*)

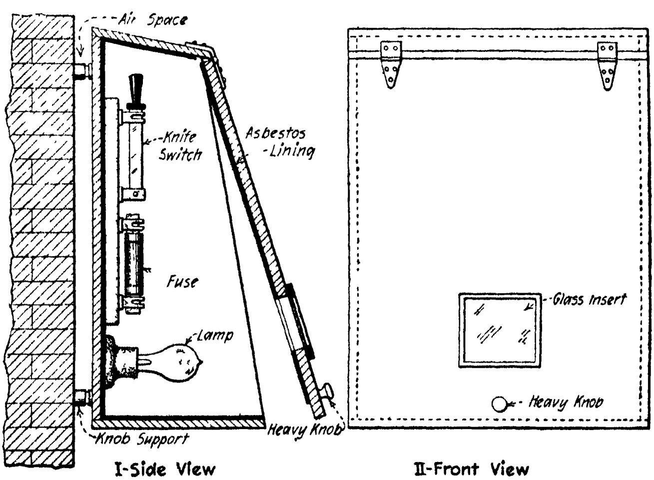
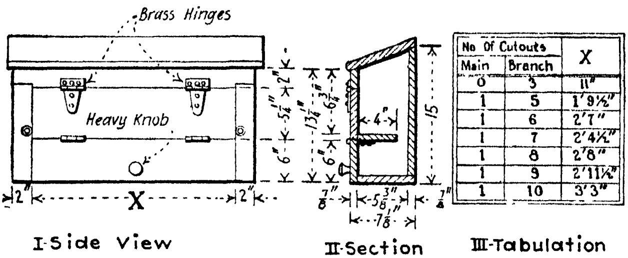



**FIG. 664.—Knife-switch-and-cutout cabinet for damp places.**

water will drain off readily. The inside of wooden cabinets should be lined with ⅛-in. asbestos board painted with asphaltum. The outside of the cabinet should also be painted with an asphaltum paint. The best hinge to use is a hot-galvanized iron or brass hinge. When snap switches are

employed, the door may be divided into two parts (Figs. 663 and 665) with a barrier, projecting at right angles into the inside of the cabinet, attached to the lower end of the upper door. This barrier will protect the employees from coming in contact with the fuses when operating the snap switches. The doors should always be made self closing. Sometimes this may be effected by fastening a weight to the bottom of each door. A pane of glass should, when a lamp




| No. Of Cutouts | | X |
|---|---|---|
| Main | Branch | |
| 0 | 3 | 11" |
| 1 | 5 | 1' 9½" |
| 1 | 6 | 2' 1" |
| 1 | 7 | 2' 4½" |
| 1 | 8 | 2' 8" |
| 1 | 9 | 2' 11½" |
| 1 | 10 | 3' 3" |

FIG. 665.—Wooden switch and cut out cabinet for damp places. (*F. G. Waldenfels.*)

is kept burning inside the cabinet, be set in the door. The light will then serve to keep the interior of the box dry and as a pilot to guide the way to the cabinet in the dark.

NOTE.—IN FASTENING THE ASBESTOS BOARD LININGS TO WOODEN CABINET INTERIORS, it is best to use ¾-in. *copper tacks.* Galvanized or plain steel tacks will do if they are well painted with asphaltum after insertion. Common *sheet asbestos* is not suitable for cabinet lining because it will, even if painted with asphaltum (and all of these cabinet linings should be so painted) absorb considerable moisture. All of these cabinet linings should be of asbestos board.

NOTE.—GOOD HOT-GALVANIZED STEEL CABINETS of No. 12 U. S. metal gage have proved satisfactory in one of the worst places—a glue house. And enameled-steel cabinet, however, is not satisfactory in such places.

**344. Conduit Wiring In Hot Dry Locations, Such As Ovens, Dry Kilns, Furnace Rooms,** and the like has been successful when properly installed. Asbestos insulated wire should be used where the temperature will be very high. For lower temperatures, slow-burning insulated wire may be employed. Neither of these insulations are effective if they are permitted to become damp; they must always be maintained dry.

Great care must be exercised in pulling in asbestos insulated wire because it will not withstand abuse as will rubber insulated wire. In certain furnace installations, bare wires have been run in lava tubes. Also in furnace installations, bare wires have been run in ducts formed in the brickwork for their reception; additional insulation was found unnecessary. Porcelain keyless sockets appear to be the most satisfactory. Sheet steel must be used for cabinets in hot, dry places; asbestos-lined wooden boxes dry out and become defective.

**345. In Places Where Inflammable Vapors Or Dust Are Present** great care must be taken that no sparks will be thrown

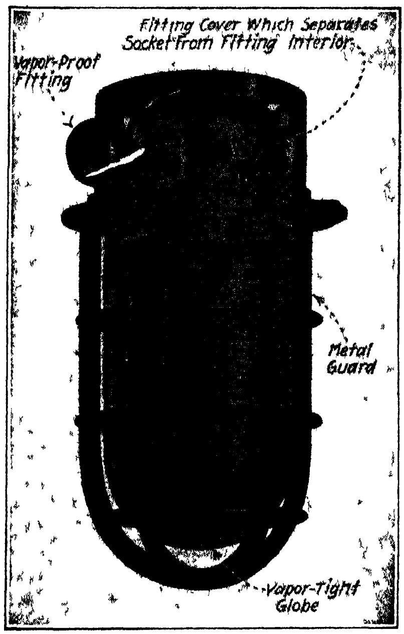



FIG. 666—Vapor-tight globe and guard. (*Crouse-Hinds Co.*)

out into the inflammable atmosphere. The conduit method of wiring is most desirable in such places because it protects the conductors and confines any fire which may be caused by a short-circuit to the interior of the system itself. To prevent fires from starting at the sockets, each lamp and socket should be provided with a vaporproof fitting and vapor-tight

globe (Fig. 666). The globe should be protected by a galvanized steel guard. Key-sockets must not be used as they often draw an arc which might ignite the inflammable material present in the atmosphere. All cabinets should be as vapor- and dust-tight as possible to prevent an arc which might be formed, from igniting the vapors present. Steel cabinets are preferable to those made of wood.

NOTE.—THE PLACES IN WHICH INFLAMMABLE VAPORS OR DUST MAY BE EXPECTED are: *Cleaning and dyeing plants, grain elevators, flour mills, saw mills, planing mills, paint shops, gas plants, oil refineries*, etc.

NOTE.—AN ACID-PROOF CONSTRUCTION FOR CONDUIT AND LAMPS (Fig. 667) which is described by W. B. Todd in *Electrical World* for

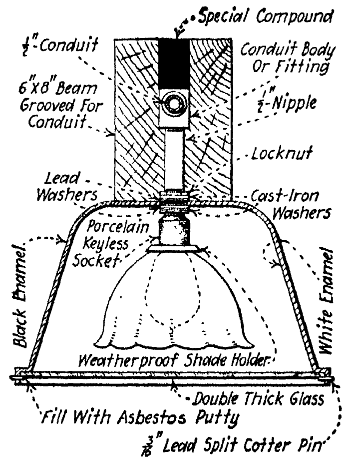



FIG. 667.—An acid-proof construction for lamps.

Aug. 14, 1920 may often be desirable. The conduit is protected by running it in a groove cut in the 6- by 8-in. wooden beam. After the conduit is laid, this groove is filled with an insulating compound. The whole of the exposed surface of the beam is then given a coating of the compound. The lamps are inclosed in a heavily enameled steel reflector, which is closed at the bottom by a double-thick clear glass. This glass is held in the reflector by means of lead split cotter pins. The cracks between the glass and the rim of the reflector are closed by a fillet of asbestos putty. A weatherproof shade holder and a porcelain keyless socket are employed. For fastening the reflector on to the nipple leading from the conduit, cast-iron locknuts and washers, in conjunction with lead washers, are used.

## QUESTIONS ON DIVISION 12

**1.** What method of wiring should be used in damp or corrosive places?

**2.** What advantages has the conduit method over the open-wiring method in damp places?

**3.** What kind of ordinary conduit is best suited for moist places?

**4.** How should ordinary conduit be protected from moisture or corrosion in damp places? Give another method which is more expensive.

**5.** State what precautions should be taken when installing the conduit in damp places. Give an example of how trouble may be avoided by planning the conduit runs.

**6.** Describe the two methods of eliminating the effects of condensation in a conduit. State which you prefer and give your reasons.

**7.** State how conduit has withstood corrosion in the following places: Tank rooms, glue houses, borax mill, pickling department, fertilizer rooms, and hair house.

**8.** What kind of conductors should be used in conduit in cold-storage rooms or other damp places and why? How should joints be made?

**9.** Describe the troubles in damp places caused by wire drops. How may some of these troubles be avoided? Are lamps close to the ceiling desirable? Explain.

**10.** Explain the advantages and disadvantages of different sockets for use in damp places.

**11.** When snap switches are used in damp places, how should they be installed? How should push-button switches be installed? Where should the switches preferably be located?

**12.** When knife switches are employed, what precautions should be taken?

**13.** Describe the construction of the desirable type of cabinet to be used in damp places.

**14.** Describe the precautions to be taken in wiring places subjected to inflammable dust and vapors.

## DIVISION 13

## CONDUIT WIRING ON MACHINERY

**346. Electrical Wiring On Machinery Should Be So Installed As To Satisfy Four Fundamental Requirements,** (Fig. 668): (1) *Safety;* that is, the wiring should be such that the likelihood of accident due to electrical shock is minimized. (2) *Convenience;* the control devices should be located where the operator may easily reach them and they should be such that the effort to operate them is as small as is feasible. (3) *Permanence;* the wiring should be so arranged that it is not likely to be damaged during the progress of work on or about the machine. (4) *Flexibility;* the wiring should be so placed that it may readily be removed whenever repairs to the machine may require it.

NOTE.—CONDUIT WIRING IS VERY WELL SUITED FOR MACHINERY (Fig. 668). Inasmuch as conduit wiring affords a safe means for enclosing all electrical-conducting parts with a grounded metallic covering, this method of wiring fully satisfies the safety requirement as listed above. A complete conduit wiring installation is as safe as an installation can be made. Furthermore, damage to the conductors themselves is practically impossible in a conduit-wiring system. Hence, a conduit-wiring installation possesses the maximum possible permanency. Conduit wiring has the further advantage that it provides a more pleasing appearance than does any other method.

**347. Either Flexible Or Rigid Metallic Conduit May Be Used On Machinery.**—Since flexible conduit is, in general, easier to install than is rigid conduit, much wiring on machinery is done in flexible conduit. For long or straight runs of conduit, however, rigid conduit is often used in preference to flexible. Very frequently a portion of a machine itself may be utilized as a conduit (Fig. 669).

NOTE.—FLEXIBLE CONDUIT MUST BE USED FOR CONNECTING PARTS OF A MACHINE WHICH MOVE RELATIVELY TO ONE ANOTHER.—Thus, since the motor, *M* (Fig. 668), must move up and down, the wiring

for the motor must, if carried in conduit, be in flexible conduit. Likewise, the electrical connection between the wiring of a steam *locomotive* and its tender (Fig. 697) must be carried in flexible conduit.

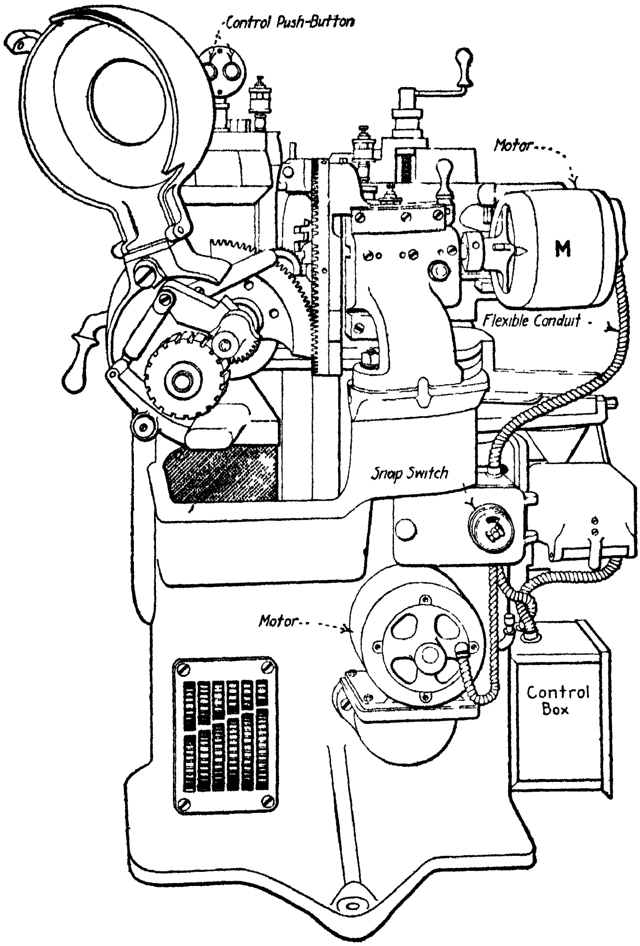



FIG. 668.—A modern 4-in. spiral bevel gear generator showing ideal electrical wiring.

**348. Motors Which Are To Be Wired By The Conduit Method Should Be Equipped With Terminal Boxes** enclosing their terminals (Fig. 670) or with *bushings* (Fig. 671). Practically all manufacturers are prepared to furnish motors with such boxes or bushings. Such devices enclose the motor

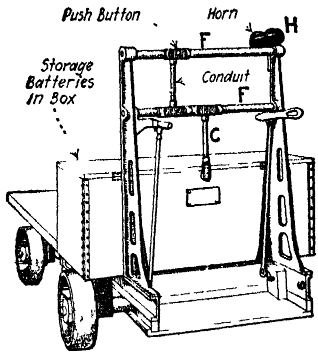



FIG 669—An electric truck on which wires to the horn, $H$, were run through the horizontal members, $F$, of the frame and through connecting conduits, $C$

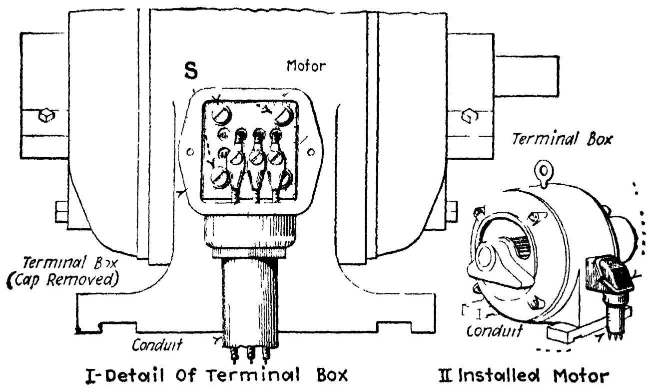



FIG. 670—Wagner motor showing terminal box enclosing the motor terminals. The base of the box is made square so that, by removing the screws, $S$, it may be turned. This permits the conduit-connection hole to be pointed up, down, or toward either end of the motor.

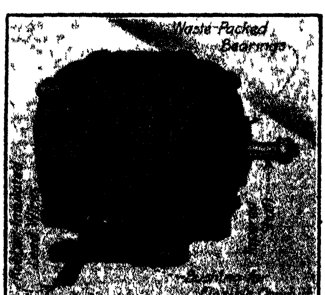



**FIG. 671.—*Westinghouse* alternating-current loom motor.**

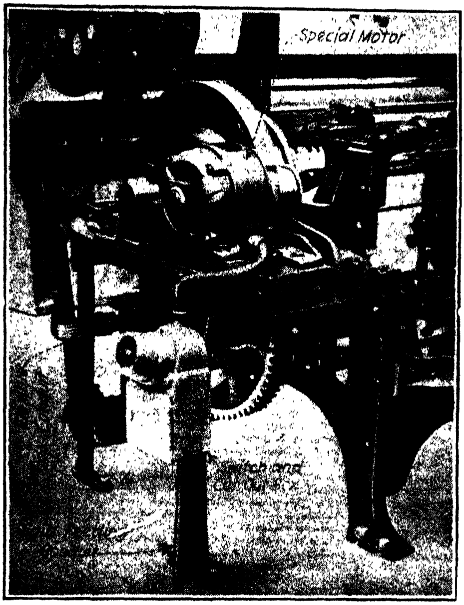



FIG. 672.—Special motor and switch-and-cutout box mounted on loom and fitted with conduit wiring. (*Westinghouse Elec. & Mfg. Co.*)

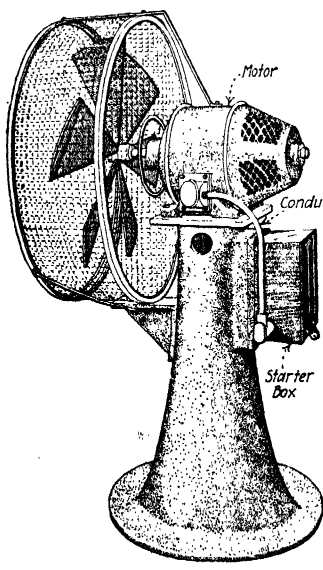



**FIG. 673.—Conduit-wiring on a 36-in. motor-driven fan.**

terminals, protecting them from oil and dirt, and preclude all possibility of damage to the conductors at the terminals. Furthermore, they automatically provide a *ground connection* for the motor frame. When connected, such motors present a very neat appearance (Figs. 672, 673, and 674).

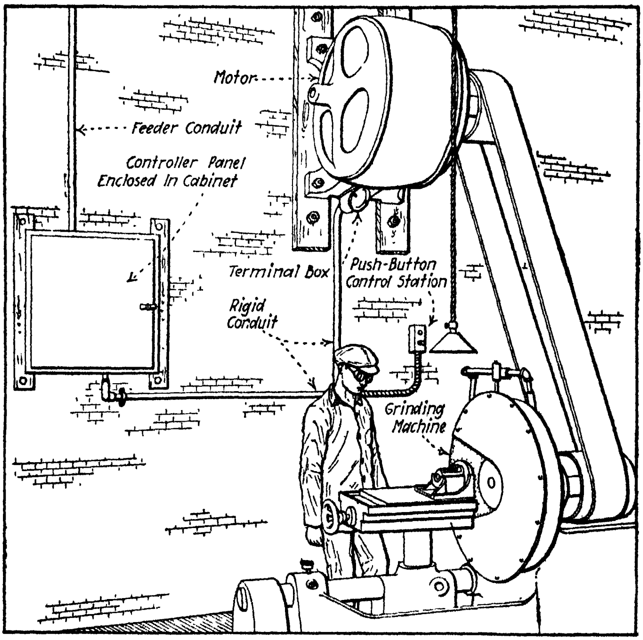



FIG. 674.—Installation of a remote-controlled motor with a pull box (or terminal box) attached (Fig. 670).

**349. Switches Which Are Used On Machinery Should Be "Totally Enclosed" And Very Simple To Operate.**—They should always have all live parts (conductors) surrounded by a substantial (preferably metallic) case. If switches or other control equipment are comparatively difficult to operate, the machine operator will be inclined to leave the energy turned on rather than to turn it off at such times as the machine is idle. This will cause a waste of energy. *Exposed live parts,* besides being an actual source of danger to the operator, tend also to increase his fear of the equipment and thus to cause

him to shun the use of the control apparatus Hence, exposed live parts also tend toward the wastage of electrical energy.

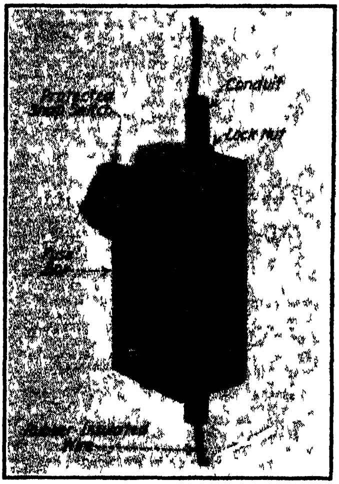



FIG 675 —Special snap switch and fuse box for textile service arranged for conduit wiring (*Westinghouse Electric & Mfg Co* )

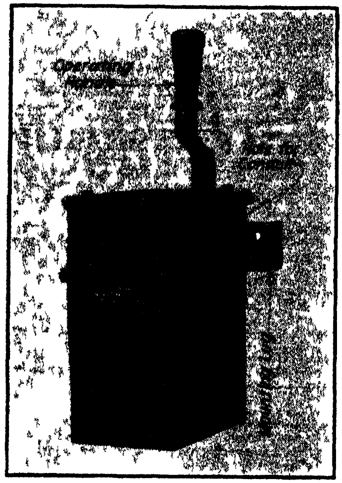
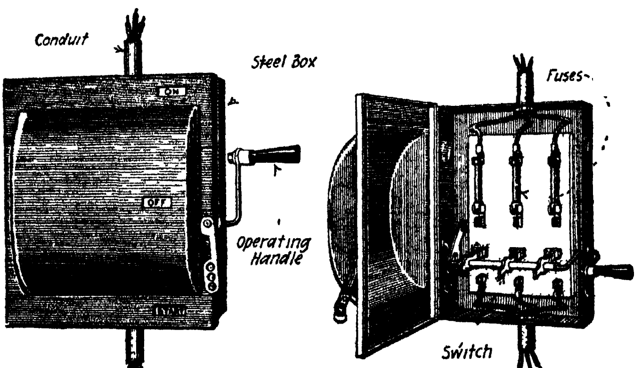


FIG 676 —Enclosed oil-switch starter, arranged for conduit wiring (*Westinghouse Electric & Mfg Co* )




I-Exterior II Interior

FIG. 677.—A *Square-D* motor-starting switch

NOTE.—THE MOST DESIRABLE FORMS OF SWITCHES AND CONTROL APPARATUS FOR MACHINERY WIRING are (1) The *plain snap switch* (Figs. 675, 672, and 668), which may be of either the rotating or push-button type. Snap switches are generally used only on such small motors as can be thrown directly on the line; hence their use is quite

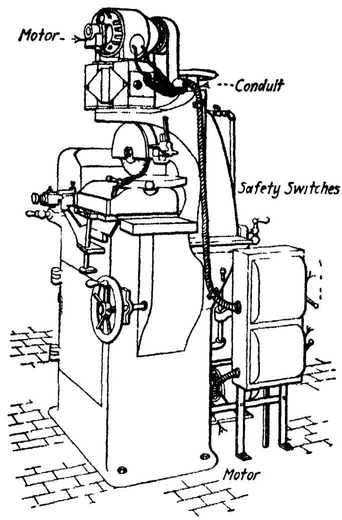



FIG. 678.—Conduit wiring on an automatic hob-grinding machine. (Note the undesirability of the exposed wires at the motor terminals.)

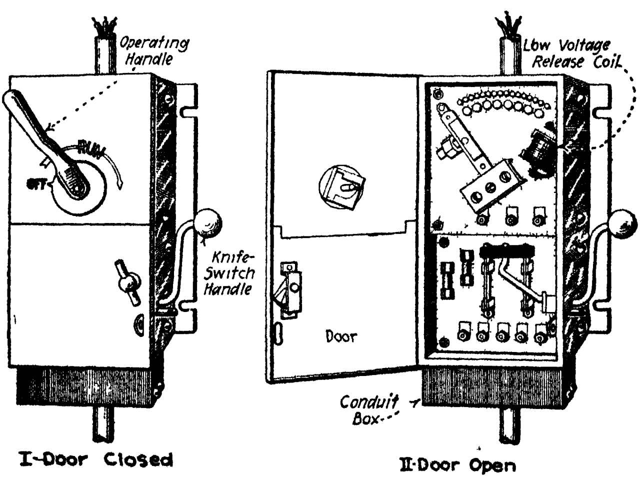



FIG. 679.—Typical enclosed direct-current-motor starting and speed-regulating control. (*Cutler-Hammer Mfg. Co.*)

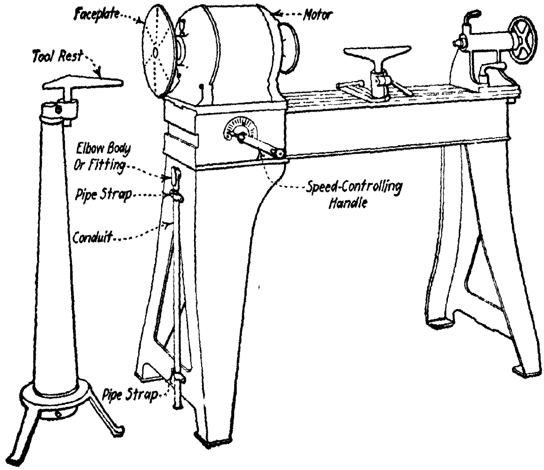



FIG. 680.—A headstock-motor wood-turning lathe with wiring all concealed. Control device is enclosed in the bed of the lathe.

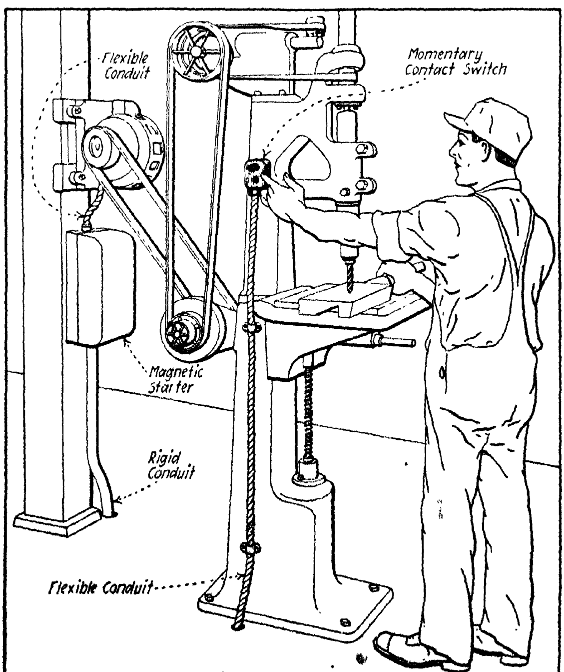



**FIG. 681.—Drill press controlled by a magnetic remote-control switch through a momentary-contact switch.**

limited. (2) *Externally-operated enclosed switches* (Figs. 673, 676, 677, and 678). These are used chiefly for starting small alternating-current motors (constant speed). (3) *Enclosed rheostats and other speed-control devices* (Figs. 679 and 680). Such control equipment must be employed

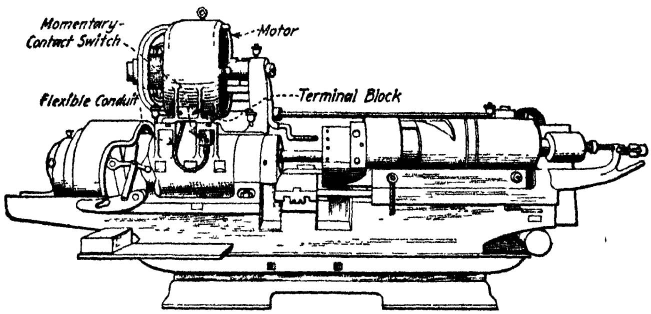



Fig. 682.—Machine having motor controlled by a momentary-contact switch.

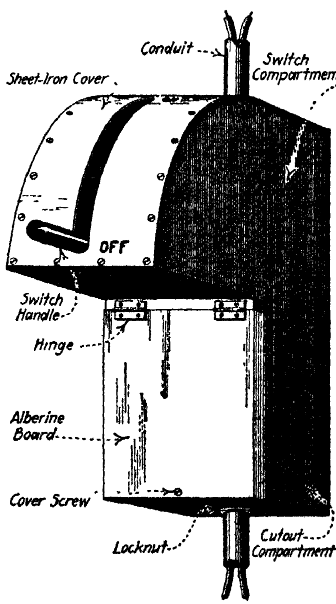



Fig. 683.—Improvised enclosing case for single-throw switch and cutout. This is constructed of alberine board and sheet metal.

on all variable-speed motors and for starting all medium or large-size direct-current motors which are not provided with automatic starting devices. (4) *Enclosed automatic motor-starters* (Figs. 668, 674, 681, and 682). Such starters are generally employed on machines which have

medium or large-sized motors, particularly when it is desired to control from a distant location.

The control apparatus for a large motor is shown assembled in Fig. 483.

**350. Improvised Enclosing Cases For Switches And Cutouts** (Figs. 683, 684, and 685) can readily be arranged in emergencies or when the regularly manufactured "safety-enclosed" switches are not obtainable. It is not ordinarily feasible to make the improvised switch cases so that they are "totally

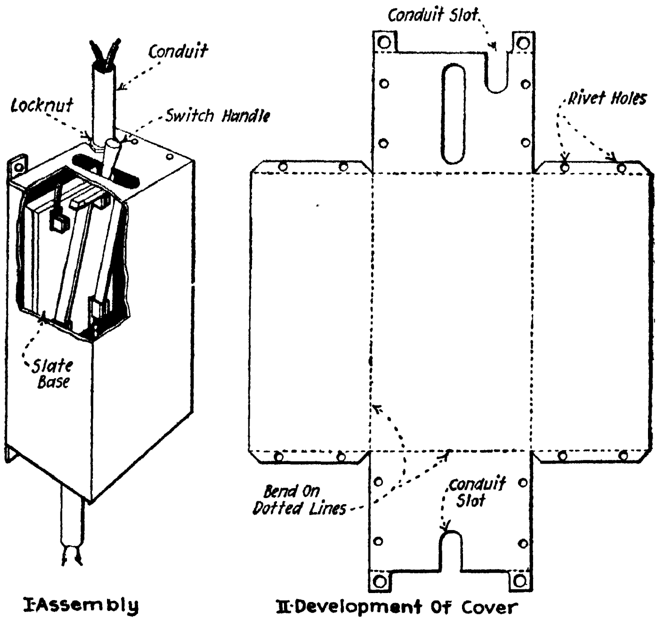



FIG. 684.—Improvised sheet iron switch and cutout case designed for attachment against a metallic or wooden surface with screws.

enclosed." Usually, in these home-made cases, a slot must be provided through which the switch handle must extend to the outside. Such a slot allows the entrance of dirt, oil and dust—which is often very objectionable. These foreign substances will not readily enter the regular manufactured safety-enclosed switch cases, which always have a metallic operating lever, extending out through the case side, whereby the switch may be opened or closed without opening the case. However, improvised cases, such as those illustrated, are very much better than no enclosure at all.

NOTE.—IN MAKING IMPROVISED SWITCH AND CUTOUT ENCLOSING CASES, only non-combustible materials should be used (except for damp places, in which, as explained in Div. 12 it may sometimes be advisable to use wooden enclosing cases). In general, for all-around service, cases of sheet steel are usually preferable. Fig. 684 indicates how such cases may be constructed. Often, however, it is easier to construct cases partially or wholly of thin (¼- or ⅜-in.) alberine or asbestos board. Regardless of the material, the finished cases should be painted, two coats, both inside and outside with asphaltum or insulating paint. In the Author's "American Electricians' Handbook" on page 494 a simple

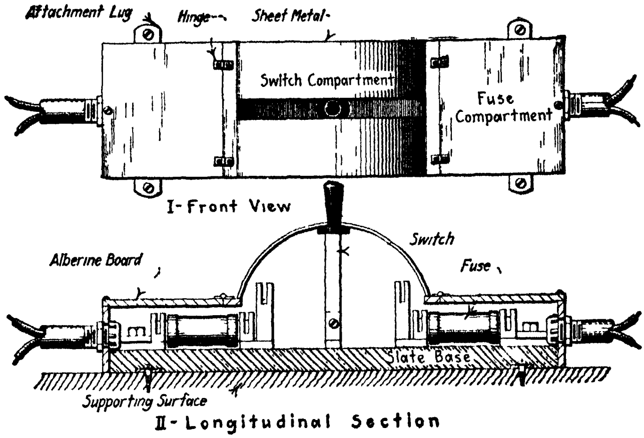



FIG. 685.—Improvised enclosing case for a double-throw fused switch.

method is shown for making a steel switch or cutout box, the door of which must be opened to operate the switch. Sheet iron for cabinets should be not less than No. 12 B. & S. gage (approximately 3/32 in.) in thickness. Joints may be soldered, brazed or, preferably, riveted It may be necessary to provide a handle longer than that which came on the switch. If so, a piece of broom handle of proper length, which has been worked to proper contour and coated with insulating paint, may be employed.

**351. The Support Of Conduit Wiring On Machinery** may, in general, be most readily and most neatly effected by fastening all conduit boxes, fittings, or cabinets to the framework of the machine (see below) and then fastening the conduit itself at as many intermediate points as may be necessary to secure the requisite mechanical strength. Often, the boxes, fittings or cabinets, if securely attached, will support the interconnecting conduit runs adequately, without additional

supports on the runs themselves. Since most fastenings to machine parts are made against metal parts, either machine screws or stove bolts are generally needed (Fig. 686). If the piece to which the box or fitting is to be fastened is such that nuts may readily be placed (Fig. 686-*I*) then stove

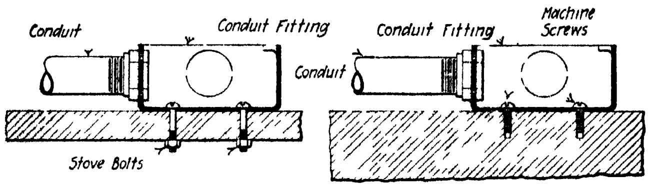



FIG. 686.—Methods of fastening conduit boxes or fittings to machine parts

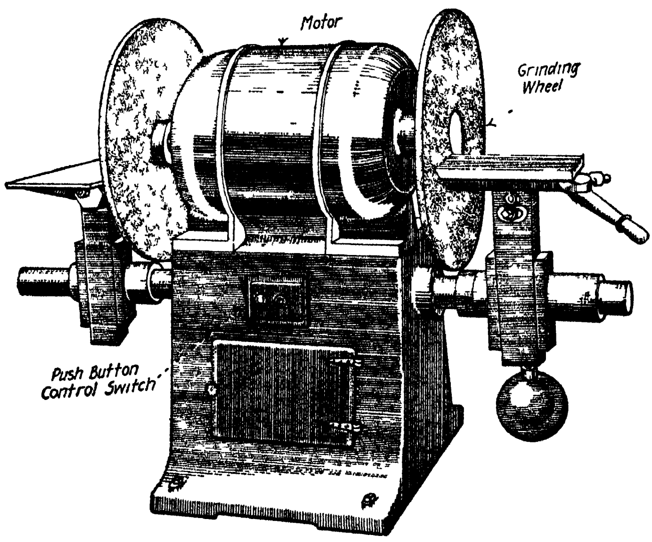



FIG. 687.—A disc grinder on which all wiring is concealed and which is controlled by a remote-controlled switch.

bolts may satisfactorily be used. If, however, it is impractical to place the nuts, then the holes must be tapped (Fig. 686-*II*) and machine screws used. Pipe straps (Sec. 65) for holding the conduit at intermediate points may likewise be fastened either with stove bolts or machine screws.

NOTE.—WHERE POSSIBLE, THE WIRING ON MACHINERY SHOULD BE ENTIRELY CONCEALED (Figs. 680 and 687). A machine with concealed wiring is more neat in appearance than one on which the wiring is exposed and is therefore more readily sold. On some machines (Fig. 682) where it is impossible to conceal all of the wiring, a neat appearance may still be provided by concealing as much of the wiring as possible.

**352. Electric Light Wiring Must Sometimes Be Installed In Conduit On Machinery** (Fig. 688). Although it is often deemed satisfactory to provide the necessary lighting for

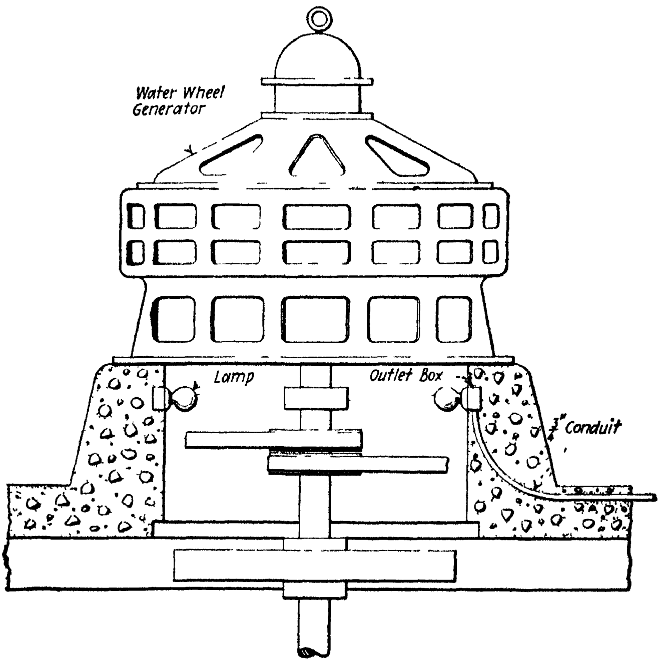



FIG. 688.—Conduit wiring on interior of the foundation of a hydraulic-turbine driven generator.

making repairs to machinery by means of extension cords, this method has the disadvantages that, when using such a light, the workman has one hand occupied by holding the lamp and often the light can only be so placed that the workman is blinded by it. In nearly all cases, it will be found better to so wire all large machines that fairly uniform light will be afforded by permanently placed lamps. Then only the auxiliary lighting need be of the portable nature.

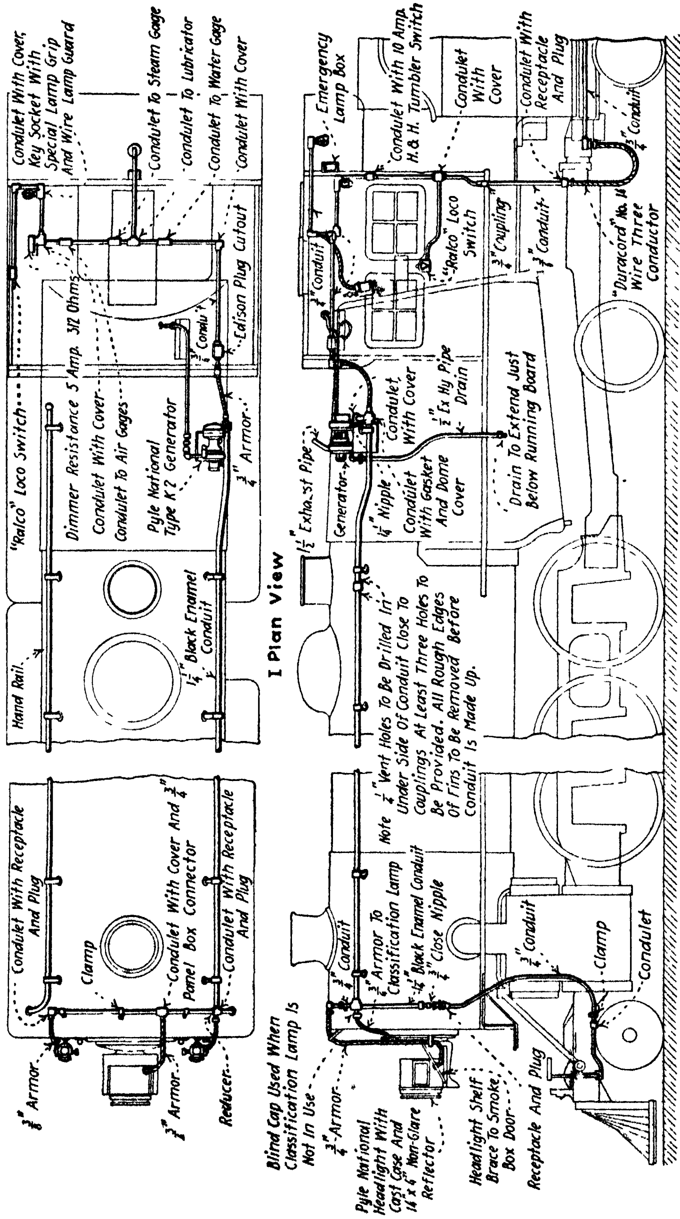



FIG. 689.—Plan and side elevation of the conduit-wiring system used on Michigan-Central locomotive.

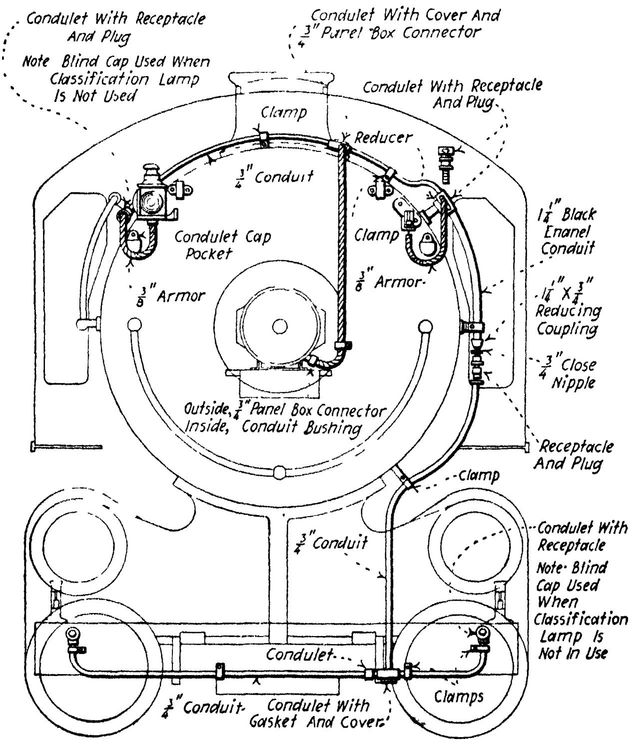



Fig. 690.—Elevation of front end of locomotive showing conduit wiring.

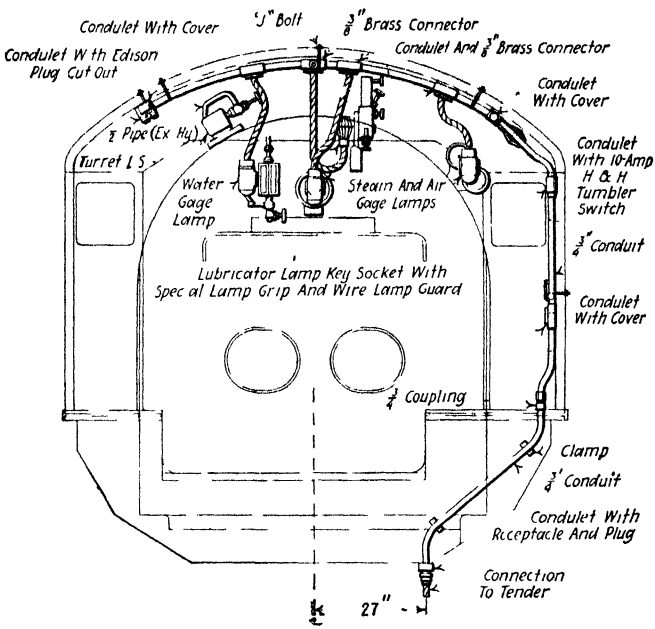



FIG. 691—Arrangement of conduit within locomotive cab.

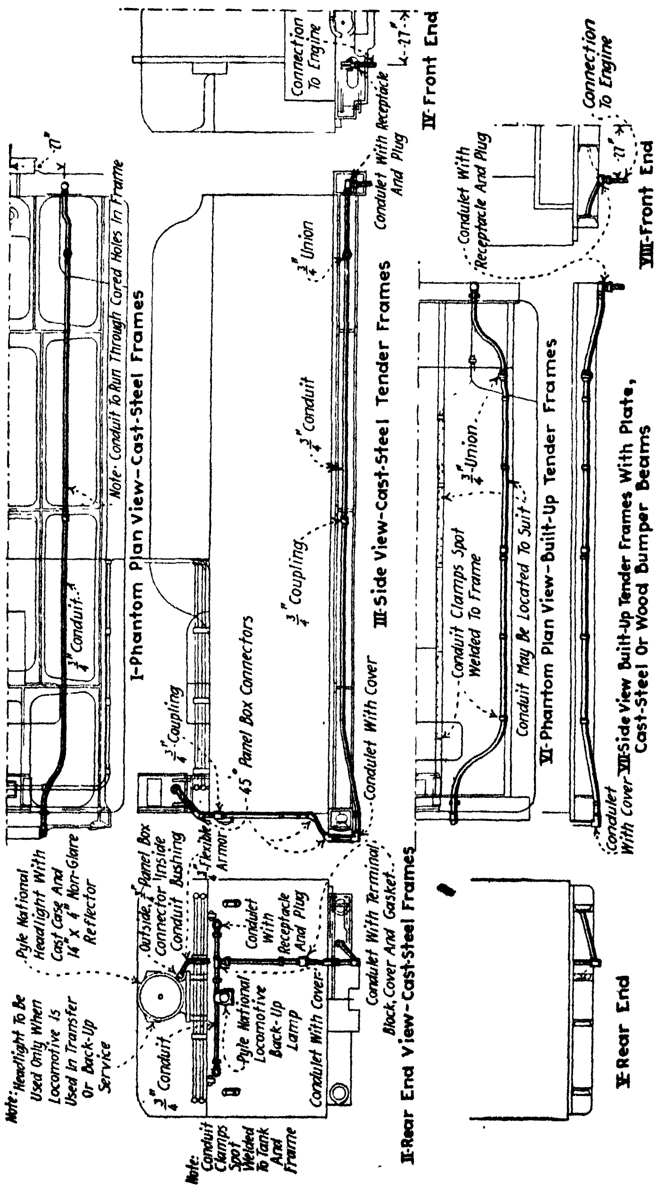



FIG. 692.—Arrangement of conduit on tender.

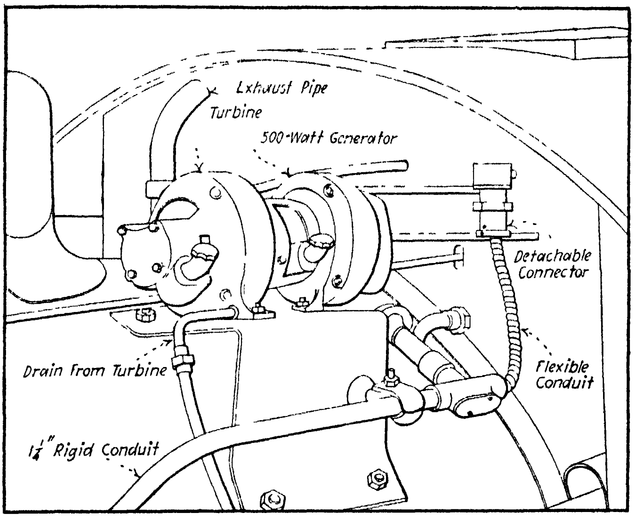



FIG. 693.—Turbo-generator and conduit wiring on rear end of the boiler of a locomotive.

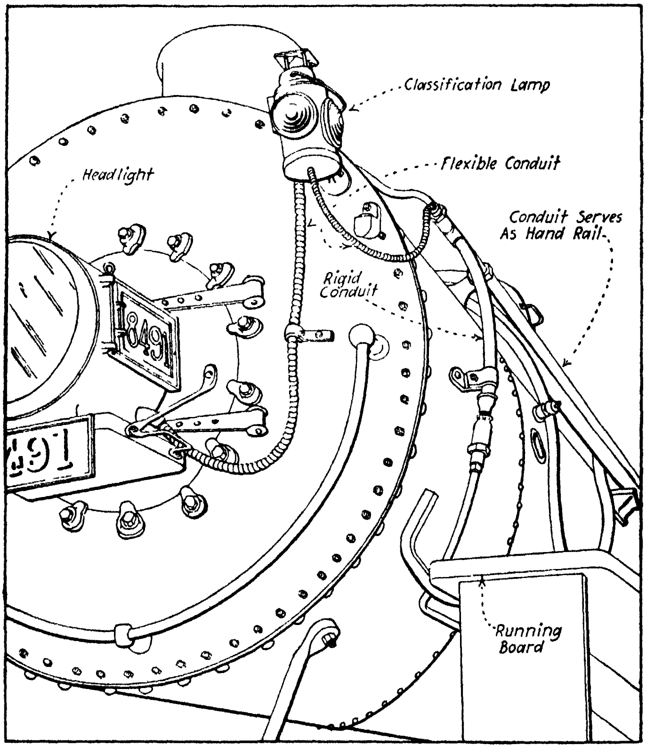



FIG. 694.—Conduit wiring on front end of locomotive

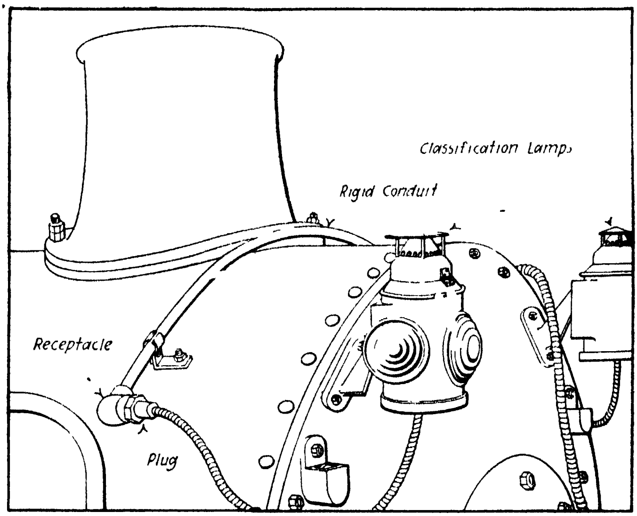



FIG. 695.—Right side of smoke box showing arrangement of rigid and flexible conduit.

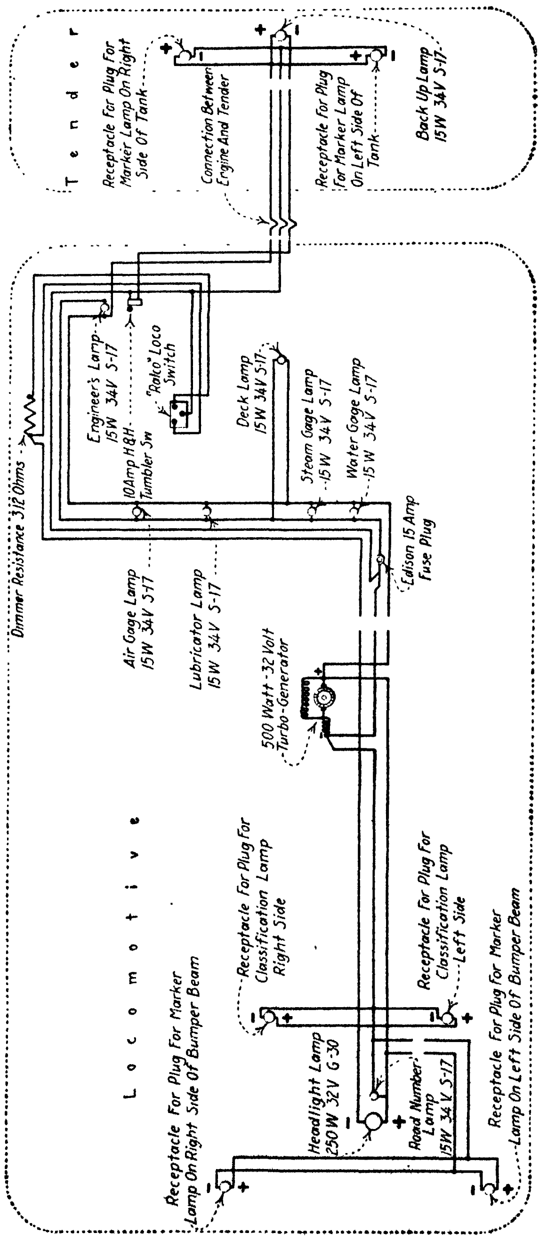



FIG. 696.—Wiring diagram of locomotive and tender.

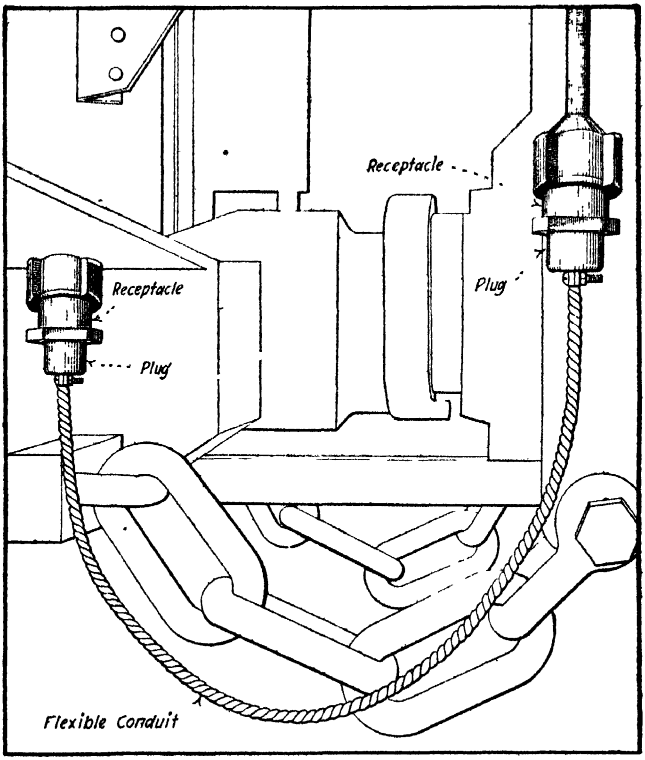



FIG. 697.—Flexible conduit and detachable connectors between engine and tender.

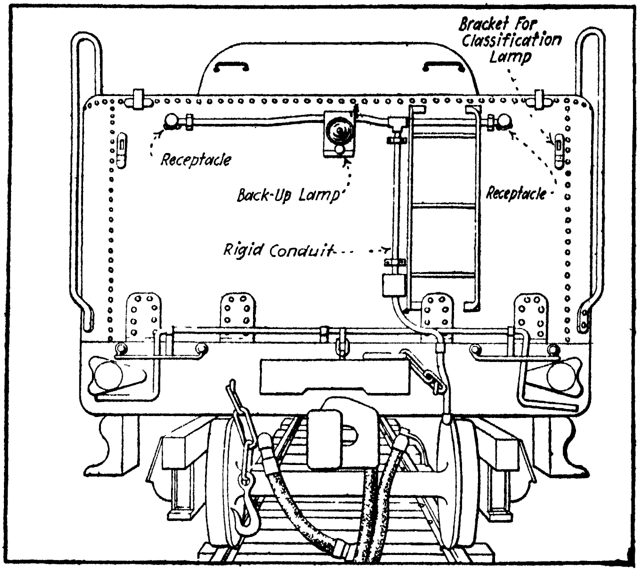



Fig. 698.—Conduit wiring on rear of tender.

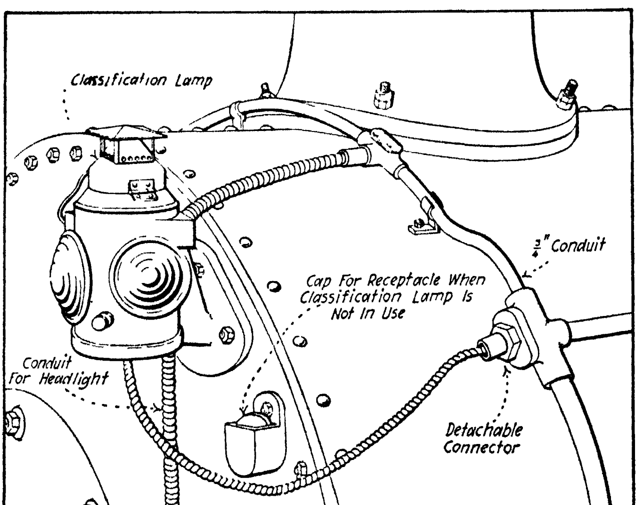



**Fig. 699.—Conduit wiring on front end of the boiler, left side.**

EXAMPLE.—THE ELECTRIC LIGHT WIRING IN CONDUIT ON STEAM LOCOMOTIVES (*Railway Electrical Engineer*, Dec., 1922) affords perhaps the best example of machinery which is effectively wired for light service (Figs. 689, 690, 691, 692, 693, 694, 695, 696, 697, 698, and 699). Although the scheme of wiring here illustrated is that which is employed by the Michigan Central Railroad, very similar arrangements are employed by practically all American railroads.

Note that a small turbo-generator is employed to supply the energy for the locomotive and tender illumination. The wiring is all so arranged

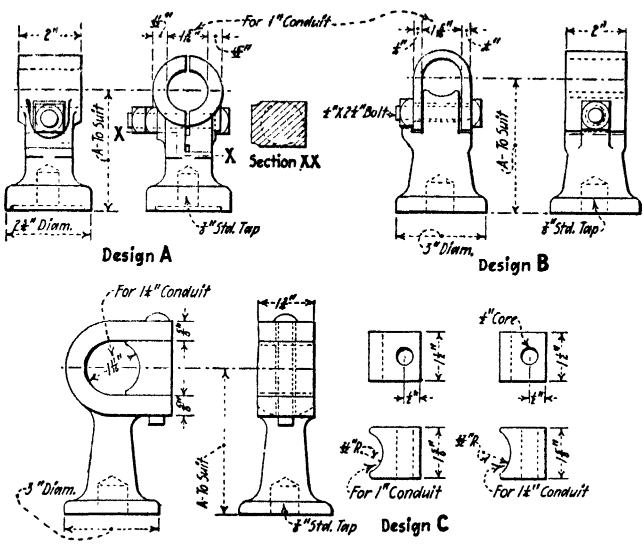



FIG. 700.—Three designs for supports for hand-rail conduit on locomotives, as recommended by the Committee on Electric Headlights of the Association of Railway Electrical Engineers.

that it may readily be removed (in sections), when repairs to the locomotive may require it, by simply disconnecting plugs from receptacles. Flexible conduit is employed for short runs wherever the conduit system may need to be disconnected and wherever two connected parts may otherwise move relatively to one another. Note also that the conduit run along the boiler is arranged to form the handrail. Recommended designs for the support of this handrail are shown in Fig. 700.

## QUESTIONS ON DIVISION 13

**1.** What are the four fundamental requirements which should be satisfied by the electrical wiring on machinery? Explain each.

**2.** Explain fully why the conduit method is so well suited for machinery wiring.

**3.** In general, what are the advantages and disadvantages of both rigid and flexible conduit for machinery wiring?

**4.** In what places must flexible conduit be employed for the wiring on machinery? Why?

**5.** What is the preferable manner of making the connections between conduits and motors? Draw a sketch.

**6.** What should be the basis of selection of switches for use on machinery? Explain fully.

**7.** Enumerate the four general classes of switches and control apparatus which are used on or with machinery. For what kind of motors is each best suited?

**8.** Describe briefly how conduit wiring on machinery should be supported.

**9.** Draw a sketch to show how conduit boxes and fittings may be fastened to metallic surfaces

**10.** Is it advisable to conceal the electric wiring on machinery? Explain fully.

**11.** Explain the advantages of wiring machines for electric lighting service. Should portable lighting also be provided for?

**12.** Draw sketches to show the method which is employed for wiring steam locomotives for electric lighting service. Enumerate the outstanding features.

**13.** Draw sketches to illustrate the three recommended designs of support for handrail conduit.

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